HIS LECTURE is dedicated to all my teachers who taught me the desire to teach others. It is further dedicated to my parents who gave and continue to give me support and encouragement.

The Chemistry of Everyday Things

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Presented in the James R. Garvin Memorial Theatre November 15, 1995

Why?

Why does Teflon stick to the pan if nothing sticks to Teflon?

Why would you turn orange if you ate only carrots?

Why isn't phonetic spelled the way it sounds?

Why do we itch?

Why do clocks run clockwise?

Why does it hurt your teeth to chew aluminum foil?

Why aren't birds sitting on powerlines electrocuted?

Why are hamburger buns so thin?

Why are left-handed people called southpaws?

Why does a golfer yell "fore "?

Why is Jack the nickname for John?

Why do doughnuts have holes?

Why do we sometimes twitch when we are falling asleep?

Why is aluminum foil shiny on one side and dull on the other?

Why do we have wisdom teeth?

Why does the price of gas end in 9/10ths of a cent?

Why is it an insult to call someone a turkey?

Why do flammable and inflammable mean the same thing?

Why are buttons on opposite sides of men's and women's shirts?

Why are apples given to teachers?

Why isn't it possible to tickle yourself?

Why doesn't air fall to the ground?

Why ask why?

Remember . . . people are born on their birthdays!

DR. MacDOUGALL, MEMBERS of the Board, fellow teachers, family, friends and students, welcome. It is a great pleasure to be here. In all honesty I was incredibly surprised on that fateful day some months ago when I was hoodwinked into attending a meeting arranged by Bob Cummings, whose alleged purpose was to meet with students to review some aspect of chemistry articulation. When I arrived, the meeting was not about chemistry articulation at all. They are so sneaky, those members of the Faculty Lecture Committee. The slides you saw as you were being seated were taken this past summer while my family and I visited Kauai for my parents' 60th wedding anniversary. Isn't that amazing? They were married very young. Maybe at age 6 or 7. They had me very late. The only question that I really need to ask about that trip is that, now that I've used the slides for this presentation, can I write the trip off on my income taxes? Important thoughts, you know.

You received several handouts along with your program as you arrived today. I hope you've carefully looked them over. There's a periodic table on one of those sheets. You will cut it out. You will carry it. You never know when somebody sitting next to you on a bus will say, "Just what is the atomic number of gold?" And you can pull out your pocket periodic table and say, "Why 79, of course." And then you can further explain that means there are 79 protons and 79 electrons in an atom of gold, and they will say, "Thank you." We encourage students to do those things, so I thought I ought to encourage you to also carry a periodic table.

Hopefully, you've figured out the recipe also distributed with the periodic table, because many of you perform chemistry in your home laboratory-your kitchen. That's what this talk is about. It's about the chemistry you experience everyday, to show you that you are indeed chemists. You do chemical things each day. We're going to look at some of those things and see how you are a chemist every day (Fig. 1).

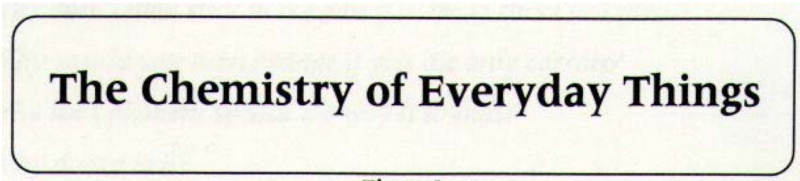


Figure 1.

Before we get into this lecture, I do feel it's appropriate to go through some acknowledgements. Not the usual acknowledgements people would generally anticipate, but those which are more broadly based. I think it is appropriate to thank the earth and planetary sciences for the Big Bang Theory, for making the elements without which we chemists wouldn't be able to do anything. So thank all of you geology and planetary people. I think it is also important to recognize the mathematicians and the physicists for the laws that govern the behavior of the small particles that make up atoms. Without these laws, who knows what might happen to small particles. We wouldn't have the kind of world we have. It's also important to recognize people in the fine arts because they rely on people, and people are biological units. So biologists get credit for making such wonderful and creative uses of the atoms we have in chemistry. They put those atoms together in novel ways so people in the fine arts can use those beings to do things like painting and dancing. Yes, I do dance in the garage to show tunes. It's very strange. I know who you talked to now, Kathy.

I should also mention chemistry. Chemistry is often called the central science because it brings together all of the different disciplines. When we in chemistry get grouchy and feel unhappy, we can always threaten to take our atoms and molecules away and leave people with absolutely nothing. We do have members of the Chemistry Department here today. They even brought their goggles. It just shows the mindset of those of us who have been breathing chemicals all those years. With all of that as an introduction, let's begin the presentation. So, Don, if you will, the next slide.

One of the reasons for showing you slides at the beginning was to illustrate the matter of chemistry. You may have looked at those pictures as having no particular focus. They looked to you like scenery pictures. When I was deciding what I wanted as slides, I thought, no matter what slides I take, they will represent a chemical in some fashion. If I take pictures of animals, if I take scenery pictures, if I photograph people, the ground, my shoes-it doesn't really matter. All of these things are chemicals. So I was immediately freed. I could photography anything I wanted.

What I decided would be appropriate was to take pictures of earth, air, fire and water-the four elements of the Greeks (Fig. 2). So what you saw were lots of pictures of earth. You see earth differently than chemists see earth. We say, ooh solid. You saw pictures of air. You say that's a nice sunset. Chemists say, ooh the gas laws, and we salivate. You see things like fire. You say, my, that's a nice burning torch. We chemists say, ah, fire-energy. Yes, it powers everything-endothermic, exothermic. We go crazy. And finally water. Water we look at as the liquid state, so we think of these things differently than you all do. Not our fault. Next slide, please.

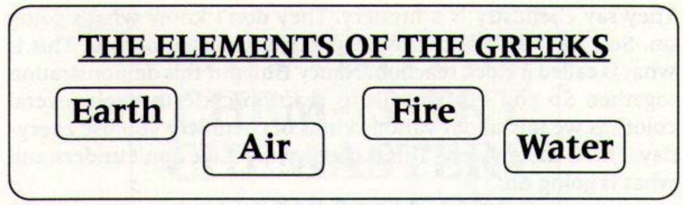


Figure 2.

We often get this response. Not the ha, ha, ha, but the oh my god, I have to take chemistry. I've always been jealous of faculty in other disciplines. People flock to the biological sciences. People come reluctantly to us until we change their attitude and say we hold all the fundamental pieces. So we change students' attitudes and end up having people enjoy and understand what they're doing on a molecular level. Next slide

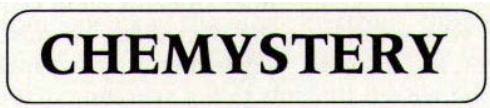


Figure 3.

This is where we begin, with "chemystery." This is what people often think. They don't understand their world on a chemical level. They say they've had bad experiences in chemistry classes before. They say chemistry is a mystery. They don't know what's going on. So I have a little chemystery demonstration for you. This is what is called a clock reaction. Nancy Hull put this demonstration together. So you can watch this reaction cycle through several colors as we talk about various kinds of chemistry you use everyday. This is the mystery. This is chemystery if we don't understand what is going on.

Later on, when you begin to understand some of the chemical principles, you have the next slide which is what chemistry is-chem-is-try. (Fig. 4). The title tells us what this is. Chemists try. If you try, if you work at it, if you understand the chemical principles behind things, then everything makes more sense.

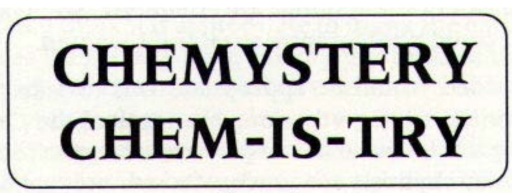


Figure 4.

In the next slide, this is what we will end up with at the conclusion of this talk-chemastery (Fig. 5).You will all be master chemists. You will understand the chemical

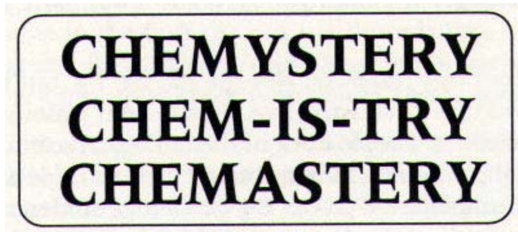


Figure 5.

principles behind many of these everyday things. If you don't pay attention to what we're talking about today, as sometimes students do in class, then you will end up with what is on the next slide-chemisery (Fig. 6). And then you say, my gosh, why is chemistry so tough? One reason is because we tell students to tell everyone that chemistry is tough. This way you can show everyone how brilliant you are. Next slide, please.

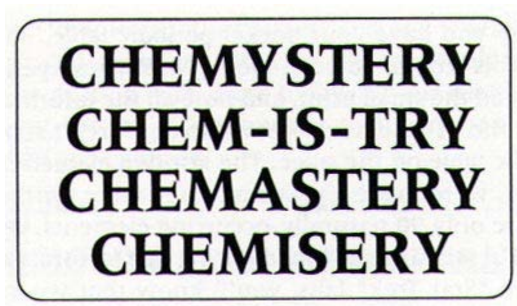


Figure 6

There once was a ride in Tomorrowland at Disneyland, Adventure Through Innerspace, sponsored by Monsanto (Fig. 7). What was fascinating was that you got into this little gondola and went inside a water molecule. When you got too close to the nucleus, you had to veer away. It was really popular. Do you all remember what kind of coupon you had to use to visit this ride? Yes, it was free. I went through the ride several times over the years.

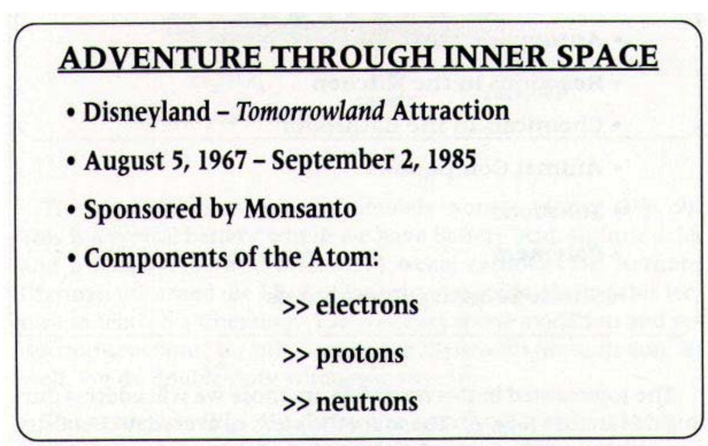


Figure 7.

The value of the ride at Disneyland was that it showed the components of the atom. Fundamentally in chemistry, we talk about the three components of the atom: electrons, protons and neutrons. There are only 111 elements known up to this time. Isn't this laser pointing device fancy? My cats loved playing with the light projected by the pointer. They chase it all around and then you turn off the light beam, and they don't know where it's gone. So we have all these protons, neutrons and electrons. Really, it's the protons that make the difference in the atoms in the periodic table.

That's why you have your pocket periodic table. So when we finish with this lecture you can look at it, if your eyesight's good enough to read the small print, and note all the information that's on here. All the 111 elements known to date aren't shown on the large periodic table on the stage. The last two elements, numbers 110 and 111, were made a year ago. They were synthesized in a lab. There are only 90 naturally-occurring elements. Of those 90, only a handful will be mentioned during this lecture. For those of you who are "Star Trek" fans, you'll know that we are carbon-based units. Directly below carbon in the periodic table is the element silicone. Some of you Trekers may remember one of the early episodes of "Star Trek" where they talked about silicone-based creatures. That all comes from the periodic table. We will be dealing with the elements of the periodic table as we go along in this lecture.

The topics listed in this next slide are those we will address during this lecture (Fig. 8). These are the areas of everyday chemistry we will discuss. These are chemical things that happen when you're in your car, kitchen, the bath, and with animals. Yes, solutions, polymers and finally some shock-sensitive compounds. I'll show you slides relating the kinds of compounds you come into contact with each day and demonstrate some of these chemical principles. Next slide.

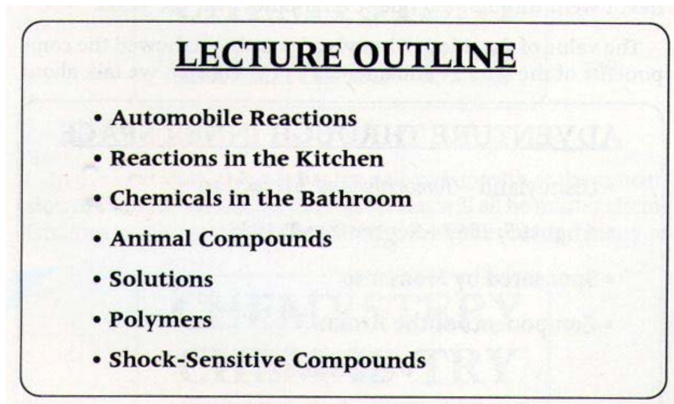


Figure 8.

This slide shows the chemical reactions which occur in automobiles. Most of you, I imagine, drove here today, or perhaps took a bus. I know some of you may have ridden your bicycles. That would be the topic for another Faculty Lecture, wherein the Kreb's Cycle and energy transport system in biology would be discussed. We won't be dealing with those today, but for those of you who came in a car, we can talk about the chemistry you experienced while driving your vehicle.

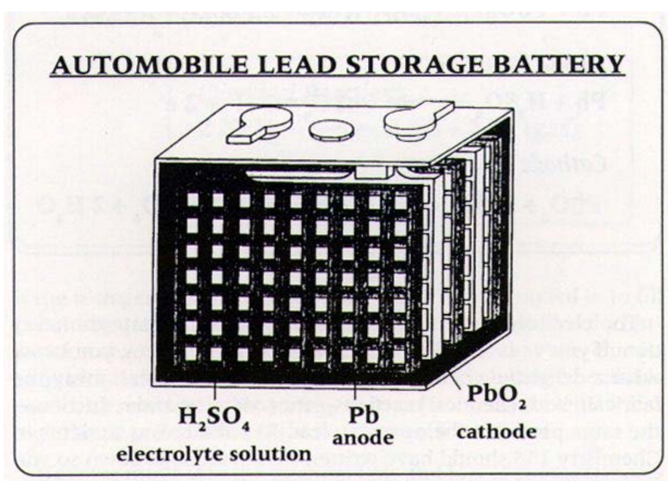


Figure 9.

The next slide shows an automobile storage battery (Fig. 9). This is a typical battery where we have battery acid, sulfuric acid, and a lead anode and a lead(IV) oxide cathode. Dr. Bernard Brennan informed me I had to introduce material during this lecture to teach his Chemistry 156 students about oxidation and reduction reactions. So this lecture is a classroom presentation, as well. We do double duty whenever we can.

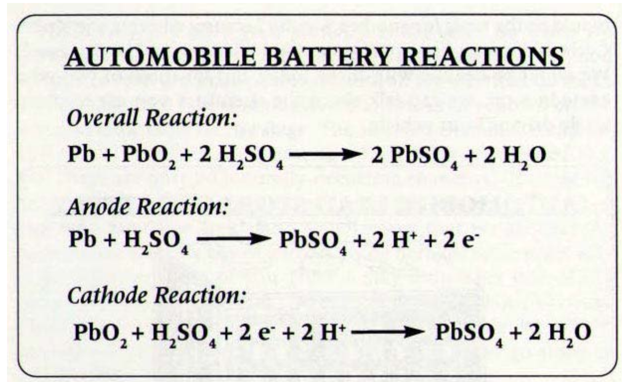


Figure 10.

The next slide (Fig. 10) shows the actual oxidation and reduction reactions within the battery. When you put the key in your car's ignition to drive here, ideally it went vrooom. If these battery reactions don't occur, no sound is made. Your dead battery doesn't start the car and you say things a sailor shouldn't say. This is what's called the anode reaction. Electrons are being produced. The electrons produced in the oxidation reaction are used in the cathode reaction. There are lead plates in the battery which are oxidized in the anode reaction. Lead(IV) oxide is reduced in the cathode reaction. All that lead makes a battery heavy. That's why when you pick up a battery, it indeed weighs a lot.

The electrolyte, sulfuric acid, is in there to facilitate the reaction. If you've ever spilled battery acid on your clothes, you know what a delightful chemical experience that is, as it eats away the fabric. In both chemical reactions-the oxidation and reduction- the same product is being made, lead(II) sulfate. You students in Chemistry 156 should have written those reactions down so you can get this correct on the next lecture exam. Your exam is on Monday. Next slide, please.

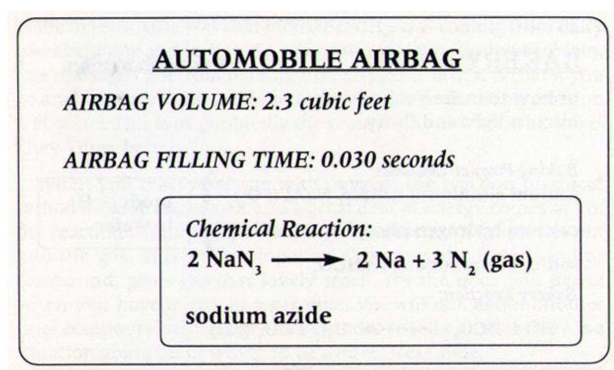


Figure 11.

Hopefully, you didn't need to perform this next reaction. These are airbags inside a car (Fig. 11). Had you managed to get your car started today using the battery reaction to provide sufficient voltage for the starter motor to achieve the actual combustion part of getting a car going, ideally you didn't end up suddenly stopping on the freeway. The airbag inflation process outlined in this slide is the one which occurs if you suddenly stop. If you have a driver's side airbag, this airbag inflates. If you have a passenger side airbag, it also inflates. If you're like me and you have neither, then maybe you'll die. Next slide.

This is the reaction which occurs to inflate the airbag. Sodium azide is the compound responsible for the quick inflation of the bag. Initially, when people were trying to develop a workable airbag, they had a lot of trouble finding a reaction that would inflate an airbag fast enough. The airbag has to inflate before you start going forward, and it's doing this by using an unstable compound which breaks down into sodium metal and nitrogen gas. It is the nitrogen gas, along with the air, that's being pulled in to fill the airbag quickly so you go face first into the airbag. This de-composition reaction of sodium azide is the reaction that was chosen to quickly inflate the airbag. Again, hopefully you didn't need this particular reaction this morning. Some of you may have had that experience previously. I hope not. So much for the car.

Now we move into the kitchen. Lots and lots of chemistry goes on in the kitchen. For those of you who bake, you know that many chemical reactions occur in your kitchen laboratory. There is a baking reaction shown in the next slide (Fig. 12). These reactions happen when you bake things like pancakes-ah, that sounds pretty good right now-waffles, cakes and biscuits. Sometime you may have the experience of not remembering to add all the ingredients while baking and, instead of making those light, fluffy baked goods, you've made doorstops.

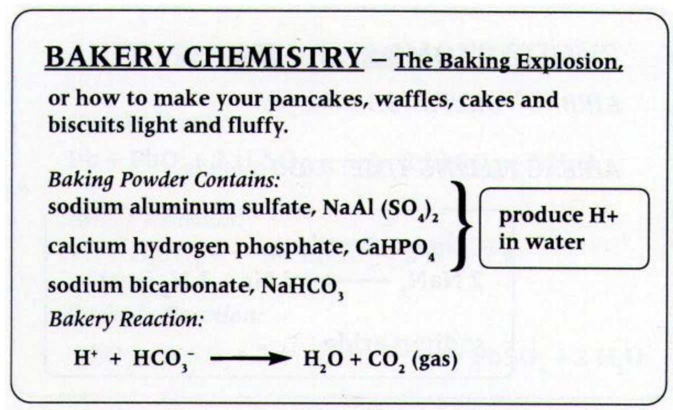


Figure 12.

You need to add baking powder when using those recipes. If you don't add baking powder, which has the compounds of sodium aluminum sulfate and calcium hydrogen phosphate, your baked goods will not rise. These chemicals are in baking powder to produce hydrogen ions, H1+, like hydrogen gas without the electron around it. When water is added to the mix, H1+ is the material that reacts with the sodium bicarbonate in the baking powder in a reaction where H1+ couples with HCO31-. We will see this reaction later in a different context to make water and carbon dioxide. Now you know why baked goods rise and form these little pockets in them. These little voids in the baked goods are a result of generating carbon dioxide in the baking process. So if your friends bake and don't always remember to put baking powder in their biscuits, don't eat at those people's houses. Next slide.

Many of you have natural gas at home (Fig. 13). Some of you have natural gas now. This combustion reaction between methane and oxygen occurs unless you have an electric range. I read an article a number of years ago about methane, CH4, natural gas. It was determined that this substance is responsible for one of the major pollution problems on the planet. And the comment they made in thearticle was that methane, CH4, was coming from dairy cows belching and farting. So cows

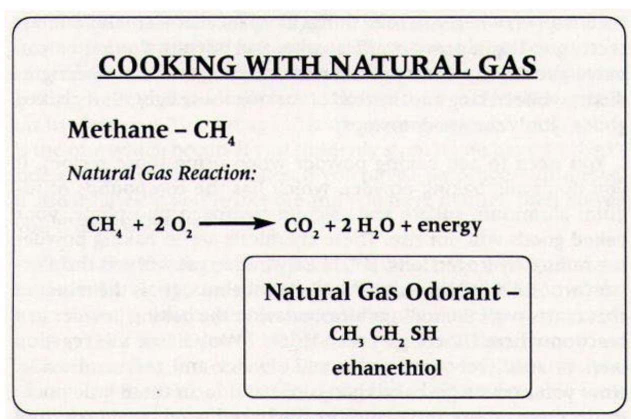


Figure 13.

are a major pollution problem. The message I got from reading that magazine article is that if you go and visit a dairy, don't smoke because this combustion reaction will occur. This is undoubtedly the reason why cows don't smoke. They know better.

When you react methane with oxygen, the reaction produces carbon dioxide and water, and a great deal of energy comes out of the reaction. Natural gas is odorless on its own. An odorant is put into the gas. This thiol compound shown in the slide, a sulfur compound, gives gas that lovely smell. It's the odor you detect when you have a leak in a gas pipe. We will talk about another thiol compound which has a similar odor to tell you that there is a situation going on of which to be aware. Next slide.

The aspartame molecule in this slide (Fig. 14) is a little more involved, but it's OK. It's worth the effort to understand what these structures mean. This molecule is NutraSweet® which comes from aspartic acid and phenylalanine. I put this molecule in this lecture for all the biologists here today. Biologists love this stuff-molecules they can relate to. The "asp" in the word aspartame, comes from the part of the molecule shown. Here is the methyl ester, that may represent the "me" in aspartame. NutraSweet® tastes much sweeter than some of the other sweeteners available. One lab partner of mine, George Muller, worked on a substitute for NutraSweet®.

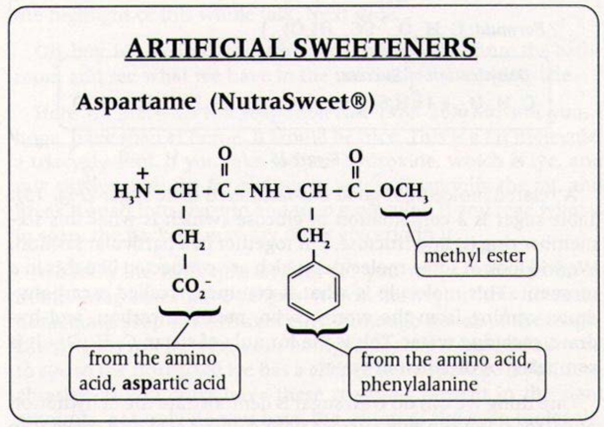


Figure 14.

Chemists are trying to make sweeteners that taste even sweeter, and they're trying to synthesize molecules that your body doesn't recognize. So when you eat these molecules, you get a rush of sweetness and feel so good. Your body doesn't recognize the synthetic molecule, and can't metabolize it. The molecule goes straight through your body. You get none of the calories derived from the sweetener. So the structure shown is the molecule NutraSweet®. The six-member ring on the bottom of the molecule-there are carbons everywhere in the ring breaks-is called a benzine ring. With a CH2 group attached, it is called a benzyl group. I thought you'd appreciate seeing the compound that's responsible for giving you all that sweet flavor. Next slide.

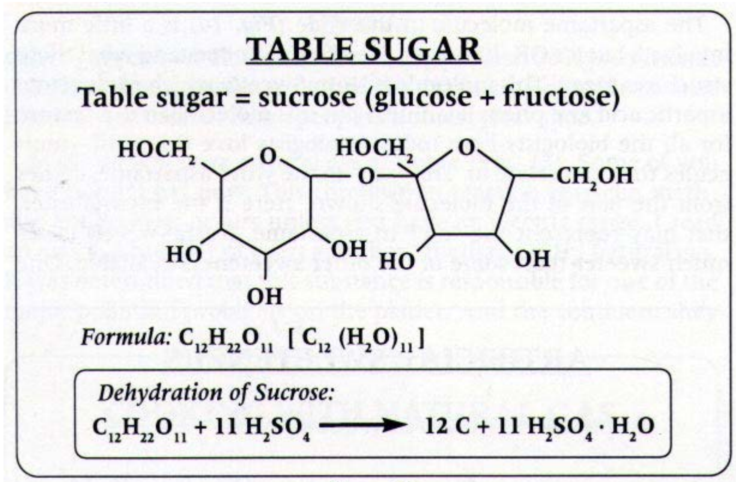


Figure 15.

A related molecule is good old-fashioned table sugar (Fig. 15). Table sugar is a combination of glucose (which is what this six-member ring is) and fructose, put together in a particular fashion. We will look at some molecules which are connected like this in a moment. This molecule is what is commonly called a carbohydrate, coming from the words carbo, meaning carbon, and hydrate, meaning water. This is the formula of sugar, C12H22011. It is composed of carbon and water.

One thing we can do with sugar is demonstrate the dehydration of sucrose. We can mix sucrose with sulfuric acid and cause it to dehydrate. This is one of those clever little demonstrations that I can perform for you. This liquid is sulfuric acid. This is what is in your car battery as the electrolyte, but it is in your car battery as a more dilute solution. This is a stirring rod. If you wanted to amuse and amaze your friends at a restaurant, you could go out and get the battery acid out of your car, pour sugar into a glass, add the sulfuric acid, and stir it until you get this soupy paste to prove that you can dehydrate sugar. It probably doesn't taste very good right now. Isn't that spectacular?

All chemists know how these demonstrations go. Sometimes there are delays in these things, but you just have to learn to enjoy the pause. It's getting darker, it's getting black. It's beginning to look like the swamp thing in there. If I knew soft shoe, I could do that-but I don't know soft shoe. You'll just have to appreciate my purple goggles instead. Well, it didn't take this long for this demonstration the other day. However, good things are worth waiting for. It would be nice if this thing cooperated and did what I would like it to do. Phew! This is why there are very few people sitting in the front row.

Here it is! What's left in the container is carbon. One of the benefits of running this particular demonstration or reaction-in case you're out of briquettes at home and you happen to have lots of sugar and sulfuric acid in the garage-is that you can produce your own charcoal! That's a dehydration of sucrose-and that's the highlight of this whole talk. Next slide.

Oh, boy, let's go into the bathroom. Let's all crowd into the bathroom and see what we have in the medicine chest. Next slide.

Here we are. This is a soap molecule (Fig. 16). Most of you, I hope, have soap at home. It would be nice. This is a fat molecule, a triacyglycerol. If you take sodium hydroxide, which is lye, and mix the lye with the fat and stir it, you will saponify the fat, and break it apart into glycerin and soap molecules. If you read what is in soap, the package may say it has glycerin in it.

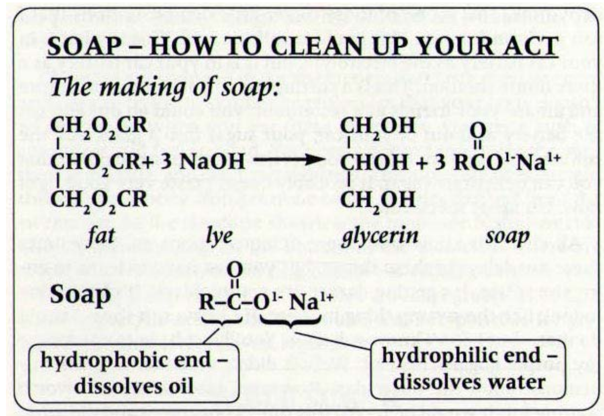


Figure 16.

We're in the right time of year for you to do this reaction at home. Magazines have recipes which show you how to make homemade soap as Christmas gifts. Although not all of the magazine articles will tell you, your homemade soap should be allowed to age so the unreacted lye has a chance to neutralize and be nonabrasive. If you don't have these reactants present in the right amounts, not only do you have the action of the soap molecule, but you have lye that reacts with the fat in your skin, which cause you to lose weight as it strips off some of your fat and makes you feel slippery.

What's going on in the soap molecule is that it has an end that is very ionic, very much water-like, the water-loving end of the molecule. The other end, the R group, which is the remainder of the molecule, has anywhere from 16 to 18 carbons in it. It is a very long carbon chain. It's not water-like. It doesn't like water. It dissolves in oil and dirt. So when you wash your hands with soap, the R part of the molecule surrounds the dirt and causes the dirt to come out of fabric, float away and get flushed down the drain.

Soap really has only been around for about 2,000 years. If you know somebody older than 2,000 years, they probably don't smell very good. People used to beat soiled clothes on rocks to get them clean. They also used to scrape their bodies down, although they really didn't do that. They just used to cover themselves with organic molecules to make them smell better. So this soap molecule is what you have in the bathroom. You have these molecules in your soap. Next slide.

The giant soap bubble recipe shown here (Fig. 17) is on one of the handouts I gave you. One of the reasons I gave it to you on a handout is because I knew that I would do this demonstration and you would want your own recipe. Do you like soap bubbles? Isn't that fun? This is "better living through chemistry." Except when the soap bubbles pop, then I get everything all over you. All right, go, go, go, soap bubble! You can make it to the last row. Oh, great. Don't break over the video projector and short out the thing.

GIANT SOAP BUBBLES

3 parts water

1 part dishwashing liquid

1 part glycerin

Stir together ingredients. Pour into a shallow pan. Make a large bubble hoop. Dip . . . blow . . . have fun.

Figure 17.

There goes technology. Ah, I'll never be invited back. Now that we've had our fun, we can move on.

Aspirin-I've told my parents this molecule would be discussed (Fig. 18).Acetylsalicylic acid. You need to know that name so the next time you go into a drugstore you can ask for acetylsalicylic acid and, when they say, huh, you can say, obviously you don't know chemistry. You didn't attend the Faculty Lecture?

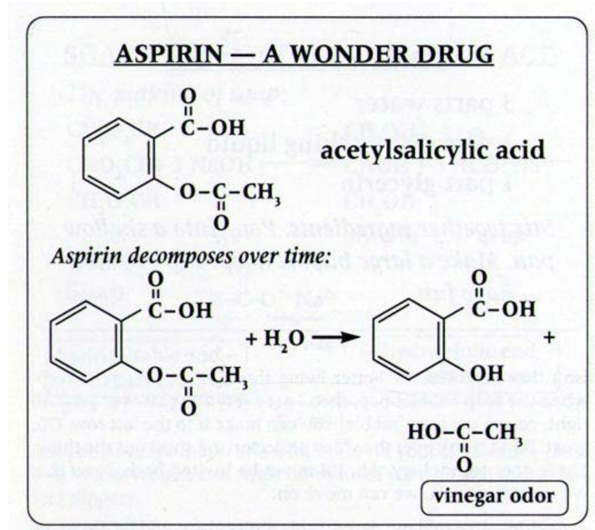


Figure 18.

On this slide is the aspirin molecule. Long ago, people would chew willow bark and found this would get rid of headaches. Just why they were chewing willow bark I don't know. They found it worked, but the problem with the molecule from willow bark, which is salicylic acid, was that it was hard on the stomach. So while it cleared a headache out, it gave them a terrible bellyache. So a small company named Bayer came up with a derivative of salicylic acid. They acylated the molecule and made acetylsalicylic acid, a molecule which did not have the negative side-effects of salicylic acid. This compound is what is in your medicine chest if you take regular aspirin.

Now I know some of you say, I don't take regular aspirin. One thing that you should all do when you go home is take a nap. No, before you do that, smell the acetylsalicylic acid, the aspirin, in your medicine chest. It will probably smell a little vinegary. If it smells vinegary, the reaction shown hereis the one occurring as we speak. Water in your steamy bathroom is breaking down the aspirin. This portion of the aspirin molecule is an ester. The water is hydrolyzing the ester, turning it back into salicylic acid. The resulting molecule still works to get rid of your headache.

This is the original substance, salicylic acid, from willow bark, but it's irritating to your stomach. This other part is why you end up with that vinegar smell, because this is the molecule that is vinegar. Vinegar is five percent acetic acid and 95 percent water. So if you wonder why vinegar is so cheap in the market, you're buying 95 percent water. We're real good consumers. I suppose if you're out of vinegar for your salad dressing, you can just take your aspirin. No, not really!

This slide (Fig. 19) is inhere for you, Ma. This is hydrogen peroxide, H2O2. If you have old hydrogen peroxide at home, you probably should test it on a cut or wound. You don't need to cut or wound yourself to do this. Just try it. It should fizz up. If it doesn't fizz, the decomposition reaction shown in the slide has occurred. In this reaction, the hydrogen peroxide breaks down into water and oxygen. What you end up with effectively is a very pure bottle of water.

Now the reason this slide is in here is that a number of years ago, when I was visiting my dear parents, I found a bottle of hydrogen peroxide in the medicine chest. Do you remember this, Ma? The bottle had come over on the Ark, back when you used to hand-letter the labels. I said, this looks rather old, and is probably nothing but purified water. My dear mother said, yes, maybe so-now put the cap back on the bottle and put it back in the medicine chest. What does her chemist son know? Yeah, right. That's when I really felt important. I'm so glad I took all those correspondence courses in chemistry. Next slide, please.

Some of you use these antacids (Fig. 20). These are the primary components in over-the-counter antacid tablets. Look at this. HCO31-, bicarbonate, carbonate and hydroxide. If you happen to make use of these things, you can go home and look on the side of the container and see that these compounds are present in your antacids. These are the primary reactions that take place. We have already seen the reaction between the hydrogen ion and bicarbonate in a previous slide, when we were talking about baking chemistry.

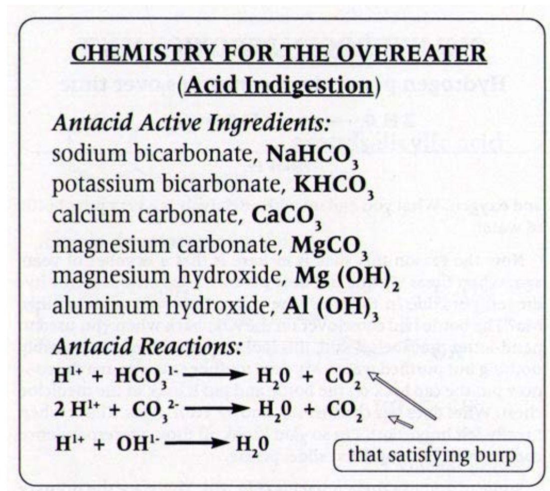


Figure 20.

Once again, hydrogen ions plus bicarbonate make H_2O and CO_2. So if you have bicarbonate in any of your antacids and you eat these to get rid of that acidic feeling, this is why you feel so much better. You're simply making carbon dioxide and, if people think you're rude when you burp, just tell them, no, I'm running a chemical reaction. You learn so many excuses when you're in chemistry. It's just wonderful. This is carbonate, much the same kind of thing, the only difference being that you have to have more hydrogen ions for the reaction. Same product. This is why you burp. If you end up with any of the antacids with hydroxide in them, you've neutralized your stomach acid with hydroxide and you just make more water. You just have to go to the bathroommore, I guess. So these are the components of antacids that you deal with as everyday chemists. Next slide.

Ah, yes. This is "The Pill" (Fig. 21). This is the substance that caused a great change in societal behavior. This structure is the natural molecule progesterone. I told you Organic Chemistry students present that there would be stereochemistry in this presentation. The pill is based on the steroid ring system. My Organic Chemistry students know how to count the asymmetric carbons in this structure. There are six asymmetric centers. Students can point them out to you, but we don't want them to show off. There are 64 different ways this molecule can be assembled, just considering the stereochemistry at those asymmetric carbons. Nature only makes one of those 64 molecules. What scientists have done is mimic the compound progesterone synthetically in making the pill, so that women can take it and not get pregnant. So this is "The Pill." Next slide.

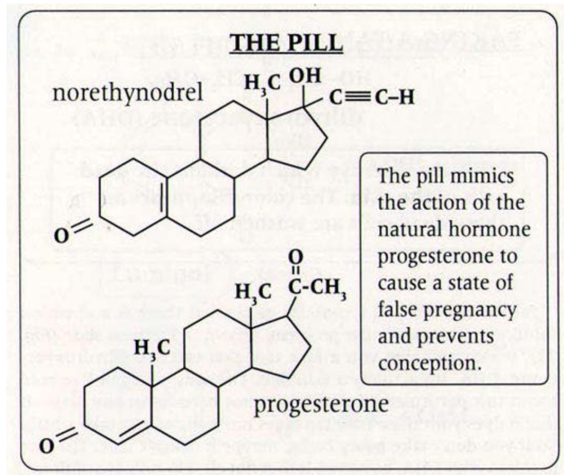


Figure 21.

For those of you who are sun worshippers, this is sun block or sunscreen(Fig. 22). When you go to the store and see all of those numbers-2, 4, 6, 8-on sunblock, all that has to do with is the varying amount of para-aminobenzoic acid, PABA, in the sunscreen. PABA protects you from the ultraviolet rays of the sun. Me, I use like 25. The next step up from that is a body bag. Pretty high. What PABA does is absorb the damaging ultraviolet radiation from the sun so it doesn't cook your skin. Some people say, well, gee, you know I have sensitive skin. I have to use PABA when I go outside, but when I use it I don't develop that glorious tan everybody else has.

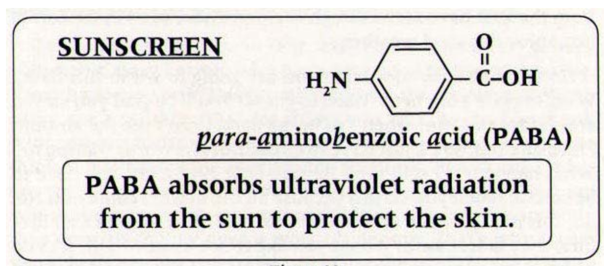


Figure 22.

People can tell that I sunburn easily, but there is a chemical solution to that particular problem, shown in the next slide (Fig. 23), which will give you a fake tan. You can use dihydroxyacetone, DHA. It's actually a skin dye. The only problem I've read about this particular substance-it's not harmful in any way-is that it dyes your skin. Your tan fades normally as you take a bath. So if you don't take many baths, maybe it doesn't fade. The one problem with DHA, however, is that not all skin cells are uniform, so you end up with a somewhat blotchy fake tan. Your elbows aren't quite the same color as your arms, your knuckles, your face. You end up looking like you had a hard day in the sun. But this is the best chemical solution for that particular situation. Next slide.

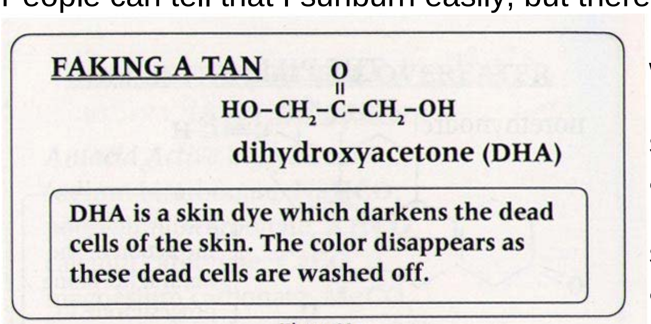


Figure 23.

Most people have animals. Let's talk about animals. On the next slide (Fig. 24), we can look at fireflies. This compound is luminol. We don't have fireflies here in California, so we have to fake things to show you what fireflies do. Now you have to watch this demonstration because fireflies are very quick. Some of you who are from the East have seen enough fireflies. Those of us in California just enjoy the good weather.

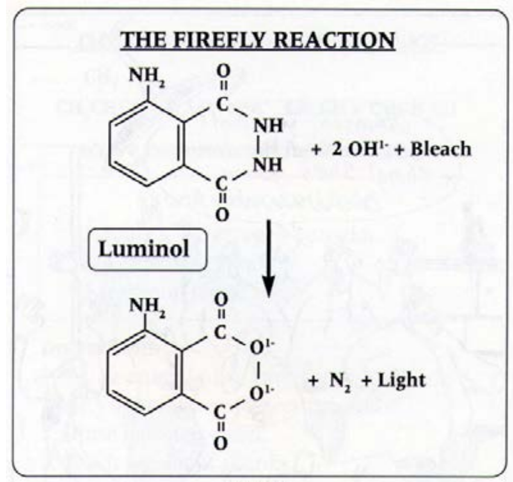


Figure 24.

Do you have any idea what you are going to see in this flask? Want to place your bets? Want to guess? You'll be glad you stayed around for this. But when I'm in the dark, I can't see the amount I measure out, so I'll just have to guess. But it is worth waiting for. What happens if I spill this? Hey, go little firefly, go! You have to be careful when you do this because all the fireflies come out. No, no, this is a synthetic firefly. Isn't that nice? But then like all fireflies, they fade. Death. Would you like to see it again? OK, let's do it again. How convenient that I just happen to have another flask.Wow! Isn't that nice? We get to do these things in the natural course of teaching chemistry. These are fireflies. They're cute little creatures. Put them in a bottle and let them glow. Next slide.

Skunks are also cute creatures. We have them here in Santa Barbara. You may have experienced these wonderful animals at some time. Dr. Larry Jon Friesen graciously provided me with this slide. That's a beautiful skunk. Next slide.

If you happen to be in this situation and are the recipient of skunk spray, the next slide (Fig. 26) shows you what to do. The skunk odor antidote is also given to you on a handout. These are two vile thiol, sulfur-containing compounds given off by a skunk. What are you supposed to do if your pet runs into a skunk? What are you supposed to wash your pet with? Tomato juice. Has anybody ever done this? How does it work? It doesn't. That's why I gave you that recipe-so you could neutralize the odor chemically and take care of your dog, cat, boa constrictor, or whatever pet has gotten involved with a skunk.

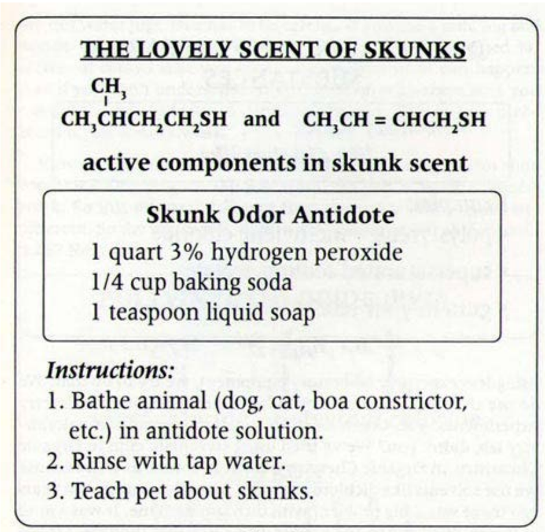


Figure 26.

This particular substance will allow you to change the thiol, using anoxidation reduction reaction. It chemically changes the thiols so they won't smell. It's supposed to work completely. In all honesty, I haven't tried this. I realize, being an experimentalist, that I should have gone out and found a skunk, should have been sprayed, and, should have tested this out. I'll leave that to you. As it says on that handout, what we're not supposed to do is store this antidote solution in a bottle because hydrogen peroxide in the mixture can build up pressure and cause the bottle to explode. The last instruction is probably the most important. You need to teach your pets about skunks. Get them to recognize that this is not a friendly animal-and they really shouldn't try to make friends with one. Next slide.

How to make things disappear. This slide (Fig. 27) shows some things we can make disappear. "Like dissolves like" is a general solubility rule. It's not quite stated this way when we present it in class because we like to talk about breaking and making attractive forces, but you don't care about the technical details. You want to use the like dissolves like idea. Like kinds of things dissolve like types of things. So I have a few demonstrations to illustrate these ideas.

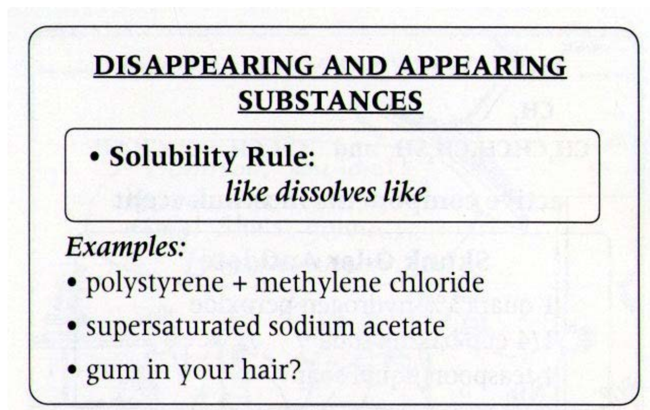


Figure 27.

We in chemistry are ever-mindful of how expensive education is. We do know that if we can save ourselves some money by using less expensive laboratory equipment, we try to do that. We do use styrofoam cups in various lab projects like our calorimetry experiments. You Chemistry 156 students just did this calorimetry lab, didn't you? We've tried using styrofoam cups in Organic Chemistry. In Organic Chemistry, it doesn't work as well because we use solvents like dichloromethane. Actually a number of years ago there was a big problem with dichloromethane. It was found in freeze-dried coffee and people didn't like that thought. I think the real problem was that the dichloromethane in coffee caused the styrofoam cup to dissolve, and this is why we stopped using styrofoam cups in the Organic Chemistry lab. So if you had dichloromethane in your coffee, you would see your cup dissolve.

OK, from what famous movie is this? "I'm dissolving. I'm dying. Dorothy, Dorothy." See, they get all these famous movie lines from chemistry. So we can't use styrofoam cups. That's an example of something that does dissolve.

Something a little bit different from that is supersaturated sodium acetate solution, which I just happen to have. This is a liquid. People normally don't like you pouring things on the floor, so I won't. I will pour it on the table. Do you have any idea what's going to happen? Are you all watching this? Will you be able to report on it at the end when we have the quiz? Instead of disappearing by dissolving, this is coming out of solution.

Do you recognize what these containers are? What are they? Not water jugs. Milk jugs. This is water. These are milk jugs. These are not water jugs. One has to be careful. If you use a milk jug and decide to put water in it-and it's not specifically designed for water-it means that you aren't anticipating what can happen. And if you don't understand what's going on with chemistry, you can get the wrong kinds of combinations and end up with problems. It just doesn't work.

Now wait a minute! Maybe there was something in this milk container. Drinking on the job again. Oh, oh. This one doesn't work. So this one was different from the other one. No, it's not different. So the message is, don't drink the water. What else could it be? Next slide.

Polymers. You've experienced polymers. Let's look at the first couple of polymers (Fig. 28). You've heard about these polymers. These are addition polymers, using vinyl chloride and polymerizing it. That just means that it has many repeating units and it makes polyvinyl chloride, more commonly known as PVC. It's a polymer, a chloride polymer, of an ethylene molecule. You've heard about Teflon. Teflon does much the same thing that PVC does. It just happens to be the tetrafluoro derivative of ethylene. Tetrafluoroethylene polymerizes, couples together end-to-end, involving hundreds of thousands of molecules, to make Teflon. This is the marvelous stuff you have in your cooking pans as a non-stick cooking surface. But it doesn't always stick so well. It does end up coming off. Next slide.

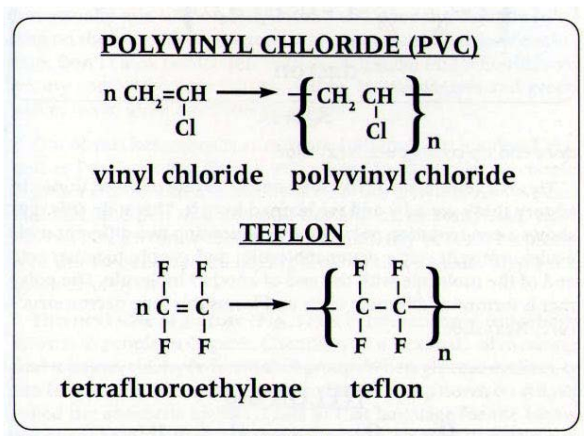


Figure 28.

This is a leisure suit. This, fortunately, is one of those things in history that's gone by and we learned from it. This slide (Fig. 29) shows a condensation polymer. By condensing two different molecules, we split out a water molecule, and couple together one end of the molecule with the end of another molecule. The polymer is formed as alternate units and forms this long dacron structure. Next slide.

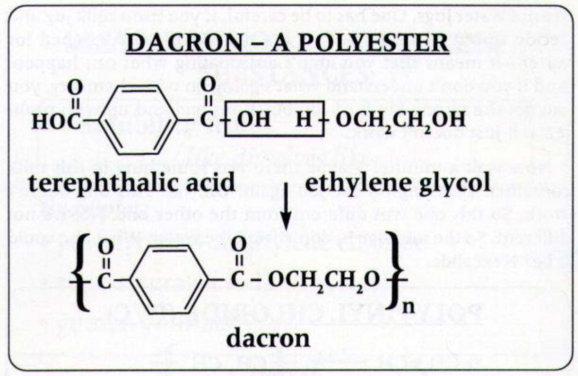


Figure 29.

This is another condensation polymer. This is Nylon 6-6 (Fig. 30). Nylon because it's a different kindof addition polymer made out of adipic acid and a diamine, a compound with two nitrogens on it. This goes through a condensation, much the same way the Dacron molecule did by coupling these two together forming a bond there, making this a long chain polymer.

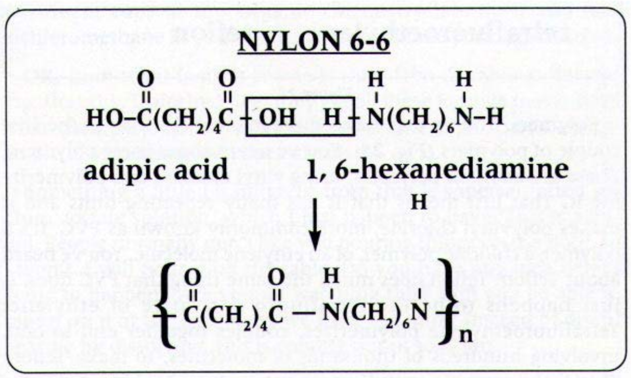


Figure 30.

Amazingly enough, I just happen to have a demonstration showing the formation of Nylon 6-6. For this demonstration, I need to put on gloves. Putting on rubber gloves always reminds me of the two most feared words males hear when they go in for a physical exam-"bend over." The two solutions I'm pouring together will not actually mix to form a solution. I will pour the diamine solution on the bottom. On the top I will pour an adipyl chloride solution. Don't I look fashionable with these goggles on? I should have on my goggles because they're purple. Purple goggles and green gloves make quite a fashion statement.

Out of this heterogeneous mixture I can pull out a nylon fiber, and as I pull out the fiber, it will allow the molecules to couple together end-to-end to make nylon. All this is nylon. And we can pull this, and pull this, and pull this and make pantyhose. Now I'm not going to draw this fiber out completely because it's pretty well drawn out. Are you having fun? So that's nylon. That's the polymer of nylon.

This next slide of glucose (Fig. 31) is in here to show you what's known to people in Organic Chemistry as a hexanal, -al meaning that it has an aldehyde functional group. When glucose cyclizes, it can form one of two rings, one with the OH group down on what's called the anomeric carbon. I toss in that language for the biologists here because they like things like that. Or the OH group can be up, so both of these molecules are identical, with the exception of the orientation of the OH group on this one carbon. And the reason for showing the orientation of the OH group is given in the next slide.

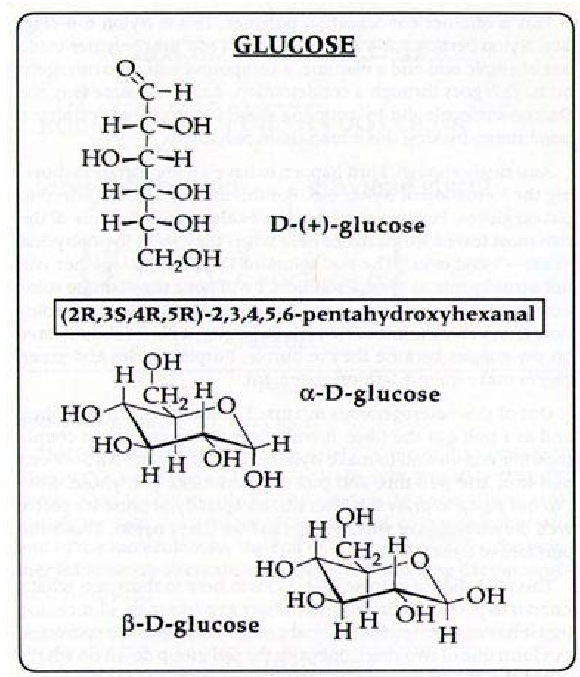


Figure 31.

In this slide, we have starch and cellulose (Fig. 32). These are polymeric molecules. They go on for hundreds of thousands of units, just as we saw in the other polymers. Starch is a polymer of glucose units, coupled by alpha-1, 4 linkages. This is the one with the OH coming down. The bottom compound, cellulose, is a compound derived from the OH going up on glucose. We eat starch. We eat crackers. You chew them, you are fueled by it. We can digest starch. You may be aware that we can't digest cellulose. If you try to eat a tree, it doesn't work out well. We don't have the enzyme needed to break this different kind of bond, this beta- I, 4 linkage, as opposed to the alpha-I, 4 linkage. So the only difference between eating trees and eating starch is just this one little bond in the molecule.

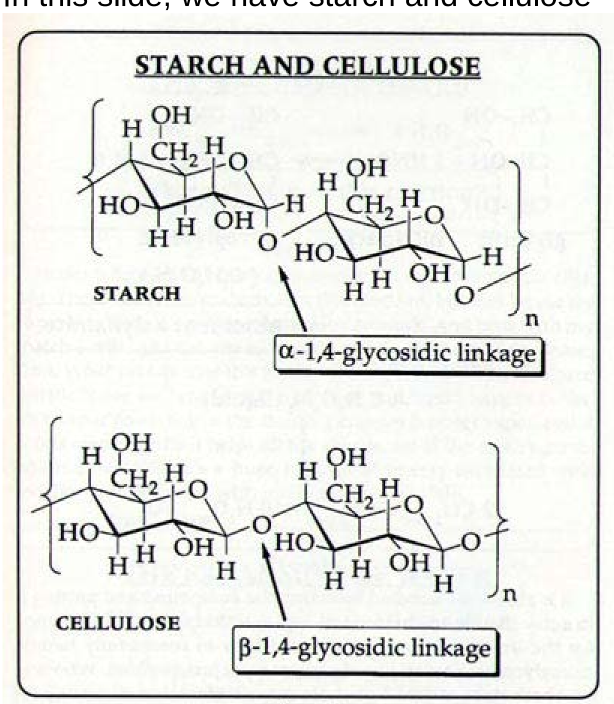


Figure 32.

There are diet breads on the market which contain cellulose. If you read the ingredients on the package, they won't quite say that they have wood in them, but they will say it's cellulose enhanced or something like that. They're not going to say it contains wood. But that's really what is in them. You would consume this molecule and not be able to digest it. Next slide.

I want to talk about a few reactions which make noise, as shown in the next slide. This is nitroglycerin (Fig. 33). I don't know if any of you have ever played with nitroglycerin. It is a very shock-sensitive compound. You make it by nitrating glycerin. We saw the compound glycerin in two previous slides. We saw it when we talked about making soap and in the giant soap bubbles recipe. I've read recipes whereby you can make nitroglycerin at home. Once you make nitroglycerin, it has a shock-sensitive nature to it or, as all chemistry students know, it has very low activation energy. If you quickly move it, it's the last thing you jiggle, because it ends up immediately turning into product. It is converted from the reactant into product.

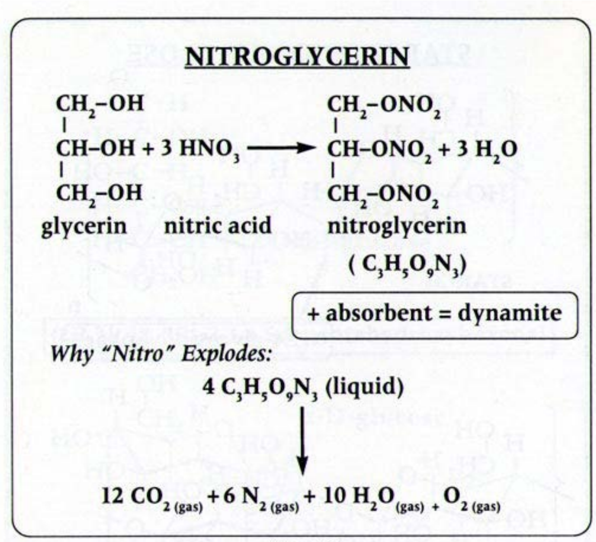


Figure 33.

It is able to be handled by taking the compound and putting it in a clay-like absorbent to make dynamite. In fact, the prizes named for the first person who discovered how to successfully handle nitroglycerin in a clay-like absorbent were just awarded. Who was it? That's right, Alfred Nobel. He made a great deal of money off this particular invention.

The thing that always interested me about nitroglycerin is not the fact that it is shock-sensitive and turns into product, because we have lots of reactions that do that. A lot of reactions go quickly from the reactants to the products. These are called decomposition reactions.

The really interesting aspect about nitroglycerin is that you start with a liquid. Liquids don't occupy much volume. When liquid nitroglycerin reacts, you make a large number of gas molecules. Gasses quickly expand and, as they rush out, the moving gasses cause people, cars and buildings to blow up. All these gasses are trying to rush out of their way. So this is what makes a successful explosive. You can read more about this in the Anarchist's Cookbook. Next slide.

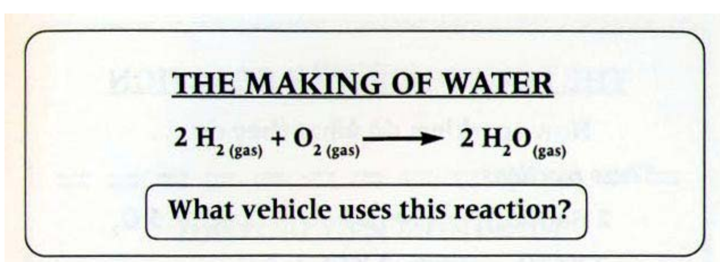


Figure 34.

Water is formed by reacting hydrogen gas with oxygen gas (Fig. 34). There is a vehicle which uses this reaction, but first let me try to get this Pringle's can demonstration to work. And now with my match I will light the top of the can. Show the next slide please, Don. What vehicle uses this water-forming reaction? On the space shuttle there are large liquid hydrogen and liquid oxygen tanks. This vapor down below the shuttle's engines is water vapor, and it is this reaction which helps lift the shuttle out of the earth's graviational field. There's a huge amount of energy associated with reacting hydrogen gas with oxygen gas. Next slide.

THE EXPANSION OF WATER

Why popcorn pops (a small explosion)

$$H_{2\,(liquid)}O \longrightarrow H_2O_{(gas)}$$

Figure 35.

Popcorn pops (Fig. 35) because the water in the popcorn kernel turns from the liquid state to the gaseous state. Once again, the water doesn't occupy very much volume as a liquid. It occupies a lot more volume as a gas. When the water expands with heat, the popcorn pops. (At this point, the Pringle's can launches toward the ceiling.) And you thought it was just a Pringle's can! This could have been the space shuttle. Now for a few balloons. This first balloon contains helium-not much of a pop. This second balloon made water since it contained hydrogen, which reacted with the the oxygen in the air surrounding it. This third balloon made a much larger noise since it contained a mixture of hydrogen and oxygen. Some of you asked me prior to the beginning of the lecture if these balloons were up here for show. Of course. Next slide.

THE FOURTH OF JULY REACTION

How sparklers do what they do . . .

These reactions . . .

$$2\ Ba(NO_3)_2 \longrightarrow 2\ BaO + 2\ N_2 + 5\ O_2$$

$$2\ KClO_3 \longrightarrow 2\ KCl + 3\ O_2$$

. . . provide heat and oxygen to cause these reactions to occur:

$$2\ Mg + O_2 \longrightarrow 2\ MgO$$

$$4\ Al + 3\ O_2 \longrightarrow 2\ Al_2O_3$$

$$4\ Fe + O_2 \longrightarrow 2\ Fe_2O_3$$

Figure 36.

Oh, Fourth of July (Fig. 36). Most of you know about Fourth of July-and that fireworks are illegal in Santa Barbara-unless you're a chemist. If you're a chemist, things are a lot more legal. Because they're not fireworks, they're chemical demonstrations, like this match that wasn't lighting. These are homemade sparklers made from a recipe I found. The reactions shown in this slide are the ones that are going on in a sparkler. Sparklers contain barium nitrate and potassium chlorate. These compounds are reacting in a decomposition reaction, producing oxygen and enough energy to make the following reactions occur. This is magnesium. Magnesium is what is responsible for the pretty white light in fireworks. These are bits of metal burning as they come off the sparkler. These are combination reactions-oxidation-reduction reactions in the burning in sparklers. Next slide, please.

Always in the past, when Faculty Lectures have been given, you have been treated to a reception. But it's different this time. Because this time you're being given permission to eat chemicals. Next slide.

What you are going to have at the reception is what we chemists refer to as dihydrogen monoxide or dihydrogen oxide or hydrogen hydroxide or hydrogen oxide or hydroxic acid. But we also call it water (Fig. 37). You may have coffee or punch-each has water in it. Next slide.

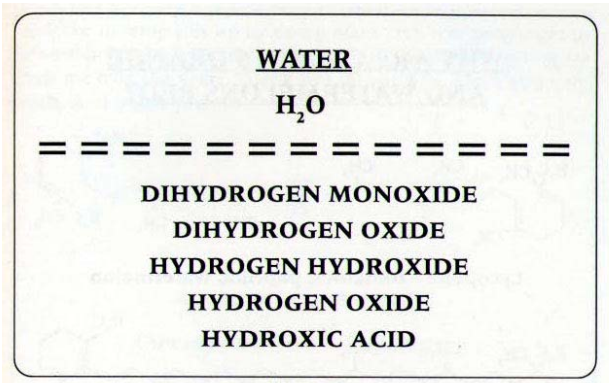
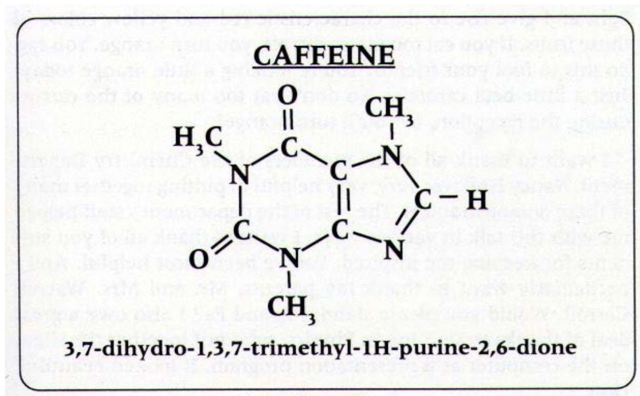


Figure 37.

For others of you, those of you who need a quick little pick-me-up in the middle of the day, here is a molecule which is a socially acceptable, addicting drug-caffeine (Fig. 38). Sure, tell me you can quit drinking coffee. "I don't need any caffeine . . . I don't need those cups of coffee in the morning . . . I'm not going to stop now." This is the structure of the caffeine molecule. If you want to remember the scientific name, this is the official name of caffeine- in case you want to order enhanced coffee the next time you go to a restaurant. Next slide.



Fiqure 38.

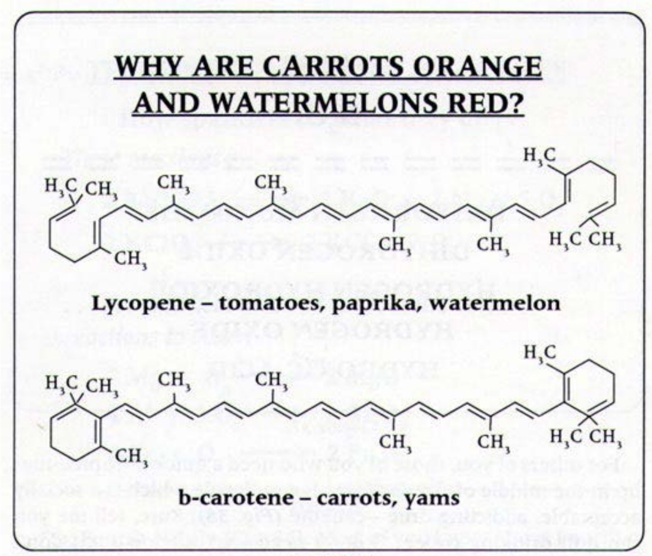


Figure 39.

These are a little difficult to see (Fig. 39). In certain foods, such as tomatoes, paprika, yams and carrots, there are lycopenes and carotenes. There are all these alternating double bonds in the structures of these molecules. What these double bonds do is absorb light and give rise to the characteristic red and yellow colors of those fruits. If you eat too many carrots, you turn orange. You can do this to fool your friends. You're looking a little orange today! Just a little beta carotene. So don't eat too many of the carrots during the reception, or you'll turn orange!

I want to thank all of the members of the Chemistry Department. Nancy Hull was very, very helpful in putting together many of these demonstrations. The rest of the department's staff helped me with this talk in various ways. I want to thank all of you students for keeping me inspired. You've been most helpful. And I particularly want to thank my parents, Mr. and Mrs. Warren Carroll. Would you please stand, Ma and Pa? I also owe a great deal of thanks to Don Ion in Physics, who put together the slides on the computer as a presentation program. It looked beautiful, Don.

I'd like to wrap this up by doing what very few people get to do-publicly acknowledging my parents for all of the help they've given me over the years. Thank you, Ma and Pa. I love you very much. And thank you all!

ACKNOWLEDGEMENTS

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All of my students - past and present

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