[SQUEAKING]

[RUSTLING]

[CLICKING]

PROFESSOR: Take a moment to look around you. Look at the person on your right. Now look at the person on your left. Turn around and look behind you and in front of you. If you have a question on mathematics, or you want to know something about the potential new elements in the cosmic dust of space, or perhaps you want to know something about the architecture of the most beautiful bridge in the world, the Millau Bridge in southwestern France, chances are there is a good possibility that someone in this class may be able to answer your question.

There are 11 different majors in this small class. This presents a great opportunity for you to actually mingle with these majors and broaden your ideas.

Welcome to 5.310. 5.310 is a non-major sequence in the chemistry department. In chemistry, in MIT lingo actually, this is a 2-8-2 course. 12 credits. In MIT policies, one credit unit is 14 hours of work per semester.

So if we look at this, we've actually got 28 hours of lecture, 112 hours of lab, and 28 hours of outside work for a total of 168 hours. But you really only have-- you're really only going to be in lecture for 17 of those hours. And there are five labs. Each lab is four days. That's 20 days times 4 hours is 80 hours. One of the labs is five days so that's 84 hours of lab.

This outside work is on the low side so I'm going to fix it. I'm going to increase that to 50. Does that make you feel good? We're moving some hours around here. And there's one more thing. 17 hours of lecture but three of the labs on day four you get out right after the quiz. You can finish the experiment in three days. I know. You're all excited about that, right? So we're really only talking 74 hours in lab here. So I'm going to increase this to 60.

So we end up with 151 hours. If you subtract those, you have a surplus of 17 hours. So I just want you to see this so that you feel good about it and you know you're not-- if you look at this and do the calculation, you're going to be spending between 10 and 11 hours a week in this course. And on the long side, if you use these surplus hours, you'll be at the 12 credit units.

Now take a look at this slide for a moment. If you look at the slide, you can see that 5.310 ties in to 5.35. 5.35, six, seven, and eight are the URIECA modules, Undergraduate Research Inspired Experimental Chemistry Alternatives. I got it all out. OK. Good.

So we've got 12 labs here. Each lab is approximately four units. And what happens is 5.310 ties into those labs. Those are the labs that the chem majors take. So what that means is if you're a freshman, if you're a sophomore or a junior, and you suddenly decide that you like chemistry and you want to change your major, or you want to double major, I'll give you full credit for 5.35 after taking 5.310. So you'll eliminate three of those modules from your program. It's a good deal.

Now let's talk a little bit about the course. So is this course useful to my future? It is an introductory laboratory chemistry course. But you will learn basic skills that you'll be able to carry away with you for the rest of your tenure at MIT and beyond MIT.

What you're going to learn in this course-- you'll learn about small scale synthesis. You'll learn about inert atmosphere techniques, thin layer chromatography and column chromatography. You'll do an atmospheric distillation and a vacuum distillation.

You'll also operate a variety of instruments. And these are the most modern instruments that you're going to find in pharma companies, in chemical companies, and industry when you go out. You'll be operating things like polarimeters, refractometers, density meters. You'll operate a tabletop nuclear magnetic resonance spectrometer, 60 megahertz just for you. You'll operate a robotic GC, an IR spectrometer, UV spectrometer, and a mass spectrometer.

You'll also get to put your samples in and watch an inductively coupled plasma mass spectrometer running. There's only two at MIT. And you also will go to the X-ray lab here at MIT. And you'll see the most modern X-ray diffraction machine from Germany running some of your samples from the essential oils lab.

In one part of the lab, you'll go on a field trip to the Charles River. Can take your lunch. You're going to bring back water samples. You'll be testing those water samples for dissolved oxygen and phosphate levels. Above all these things, you're going to learn organizational skills that you'll have with you for the rest of your career wherever you go.

Can you give me any hot tips? Students always ask for a hot tip. And I can tell you one thing that actually works for me. And that is sometimes we all get frustrated and discouraged. And when that happens, I usually find a quiet place and I talk to my brain. And I tell my brain everything is OK. Everything is going to be fine.

And time and time again, this works for me. I can get myself out of it. And if you read Oliver Sachs, in one of his books, he says that if you can imagine things, they actually can turn into reality. So are there any brain and cognitive science folks? Oh good. Look at this. I've got four of them. Can any of you offer any comments on how this helps me? Is there something there? Anyone? No takers. Anyone else?

So I guess the thinking about, you must become happier and clear your thoughts out. And if you become happier and clear your thoughts, you become smarter too. Right? And I actually brought a brain that I keep in my refrigerator, a beautiful brain. And I'm just going to set it here so that you can admire it. So the brain is very important.

Some of you in this course are very, very smart. You're all very smart because you got into MIT or at the top of your class. You're valedictorians. I recall several years ago I had a freshman advisee who came to me. And she actually tested out of every subject. She sat down and I could not find one subject to put this student in.

So I was kind of beside myself. I went out of my office and I bumped into the head of the physics department walking down the hall and said, I've got this advisee and I don't know what to do. Did you ever have one like this? He said once every 10 years.

So I went back and I put her into all the most advanced classes, some with graduate students. And then I ask her how she managed to do all this because she came from an island in the Pacific. And she said to me OCW, OpenCourseWare. I watched the lectures that MIT puts out and I learned it all myself.

But there are geniuses sprinkled throughout MIT. And there are probably geniuses in this class. Should you still take 5.310? Yes, because geniuses need practical skills. And in 5.310 can help you to bind those basic skills and make your genius become reality.

Now there are a couple other key things to help you succeed in this course. One, if you feel like you need help and you don't know what to do, you're lost, come to see us. And we'll get you back on track.

The second thing, which is important, is you need to be able to accept your mistakes. If you make a mistake, don't start crying and say it's all over. I blew this lab. I just messed everything up. I'm done for here. I don't know what to do. Just accept the mistake and ask yourself, what can I get out of this mistake that I made.

And when you do that, you really can help yourself for the long term. I mean it's not anything embarrassing if a student works for three days and then, by accident, they drop their product. It happens. So don't feel bad about it. Just come to us and we'll work something out. But don't get stressed out over it.

The last thing that could really help you here is, in this class, it's all about lab reports. So you've got to write these four lab reports and give an oral report at the end. My advice to you is don't wait until the last day of the last weekend when these reports are due to actually try to write this report out. Start early.

When you're in the lab, a four hour lab, and a lot of those labs you'll get done at four so you'll have an hour. We have beautiful write up areas in the new undergraduate chemistry lab. You can sit there. And that's the point where you can actually write out a paragraph about what you did that day, what you actually did, what you saw, and what you found. And that's your procedure and observations for your lab report. And while it's fresh in your mind, you do it. And the procedure and observations typically is about a page and a half, no more than two pages, of your lab report.

You could also work on the background of the report because you're talking about why you're doing this experiment, what you're going to get out of it, something about the history of the experiment, what was done before. So you can work on these sections along the way rather than wait until the very end and do a marathon session, try to trying to get the lab report done.

So with those things, I'd like to talk a little bit about the course. And I'm going to cover seven broad areas. One is academic integrity. The second thing is the lab policies and then, most importantly, grading, how this course will be graded.

And then we'll look a little bit at safety, because you do have a safety lecture you're going to. And we'll look a little bit at the lab notebooks that are required for the course. And we'll talk a little bit about waste management. And finally, we'll spend a little bit of time talking about calibration of instruments.

So let's start with academic honesty. MIT has one of the best integrity programs of any school that I know. They have a website devoted to it. They also have printed material that you can pick up and you can read through it. And I think probably to summarize it in just one sentence, you don't want to present as your work the efforts and product of another person.

And the penalties can be quite severe. You could actually fail the assignment. Could fail the course. You could be suspended from the Institute. You could even forfeit your degree. So it's pretty serious business.

In 5.310, I think there are two areas that you need to actually look at. One of them is there are a lot of lab reports out there. They're in the dorms. And they're in the sororities and fraternities. And they call them bibles. So you don't want to actually go out and take pieces out of those and put them in your own reports. The reason for that is it's not right to do that. And the second reason is we could have an electronic copy of one of those reports on file. That would not be good.

The other thing is I guess the innocent thing is when students sit down together and they're talking about the lab. You might talk with your lab partner. You can talk and you're writing things down. But what you don't want to end up happening is you don't want to have the same sentences in both lab reports. So you've got to put things in your own words even when you talk with each other and you're writing your reports up. That's pretty much all I have to say about academic integrity.

S the undergraduate lab policies-- you're actually picking to work on either Monday/Wednesday or Tuesday/Thursday. And depending on the safety lecture that you elected, some of you went yesterday to the safety lecture and you enrolled in the Monday/Wednesday section. Today the safety lecture is at 1 o'clock right after this class. And Tuesday/Thursday people will go there, attend the safety lecture, and then you'll go up to lab to check in your lockers.

If there are any Tuesday/Thursday people who would like to switch to Monday/Wednesday, Monday/Wednesday will have fewer students. So there'll be much better TA interaction with you. So if you can, just let Sarah know. She'll be down front at 1 o'clock registering you for your lockers. And if you'd like to do Monday/Wednesday, you can check in today. We'll just give you a Monday/Wednesday locker.

The lab itself opens at 1 o'clock every day. And the TAs will give a pre-lab lecture at 1:05. It's about a 20 minute lecture. It's going to cover exactly what you're doing in that four hour period. And they will also demonstrate some of the glassware, maybe the pipettes, and anything you're going to be using in that lab. And they'll also show you the instruments that you might be running that day.

So it's pretty important, the pre-lab lecture. And it will also firm up what you heard in the lecture and possibly didn't understand something, your TAs can really help in that respect. On the fourth lab day of each experiment, there's a quiz. And that will cover-- you've already done the three days of the experiment so you should be in pretty good shape for the quiz. You should understand what you're doing and know. You shouldn't have any problem with that.

The laboratory, we try to clean up about quarter to 5:00. I can't recall in 5.310 any time where students have to stay after 5 o'clock. That's a good thing because you want to go home. Some of you have sport practice. And we understand that.

And the last thing is we've indicated some select Fridays that are make-up labs. And there will be one Friday at the end of each four day lab period. So if for some reason you've missed something because you're sick and you couldn't do it on day four, then we have that option. And those are scheduled in the lab syllabus in your packets.

Safety goggles. You have to buy these at the VWR stockroom, the basement of building 56. And I mean, you put these on and they actually really-- they hug your face. They don't look too glamorous, but you're not going to a beauty contest. You're going to the lab. But you've got to buy a pair of these. And you've got to wear them at all times.

The other thing is your lab coat is a fire-resistant lab coat. These are top of the line lab coats. We issue you one of these when you come. We'll also give you a baggy like this. And you can write your name on the bag and hang it in your locker and leave it there. You never take it out of the lab. You leave it there. And first thing you do when you come in, at either entrance, either from building 13 or building 16 when you enter building 12, you'll have lockers. And you can grab your lab coat and goggles, put them on, and you'll be ready for the lab.

We've got plenty of gloves. We use nitrile gloves. And generally, those gloves do not give students any problems. But if you have an issue with that, just let us know.

The attire. So the lab coats have to be worn at all times. And you can't wear-- you can't come in with open-toed shoes, low cut jeans, t-shirts. You have to be really covered. So my suggestion is that you bring a little bag, a change of clothes, and you keep it in the locker. Students did this last semester. It worked really well. And then you can just change out and change out again when you're leaving. And that way you can wear your sandals, and your shorts, and anything you want, but you can't wear that in the lab.

Cell phones, radios, iPods. You have to keep those in your backpacks. And this is what the lockers look like at the entryway. So you just grab one of those. And that'll become your locker. Once you hang your lab coat in there, no one else is going to put anything in there. And we've never had any problems with the lockers in the undergraduate lab. If you want to put a lock on your locker for the semester, that's fine with me.

Obviously, no eating and drinking in the lab. You can't bring beverages and food into the lab. There are chemicals on the countertops and around that you just-- chemicals and food just don't mix.

This is very important. Report any accidents or injuries promptly. So if you do get cut or you spill a chemical on yourself, you should tell us. If you leave the lab and then a couple of days later come back and you've broken out in a red rash on your legs or arms, it's much harder for us to go back and try to figure out what happened. But if you tell us right away, then we can track it down. We know what chemical it was. We know how to treat it. And MIT Health will help with that.

If you need special accommodations or you've got medical conditions that you would like to talk about, you can come and see me on that. And you should do it this week just so we're aware of it. And I mean we don't want-- we had a student about three years ago who just passed out in the lab. I mean literally down on the floor. She was out. And if we know ahead of time if there is a condition or something that we should be aware of, we can know better how to treat that.

Grading. This is the grading scale. Pretty traditional. It's not inflated and it's not curved. So it's a traditional grading scale. And this is what we use in 5.310.

So the grading is all based on five labs. Each lab is worth 100 points. Total number of points is 500 for the course. And this will make you happy. There's no final exam. There was a final exam when I took over this course 10 years ago. But I got rid of it. It was not nice.

So you've got 500 points. And how is that broken down? So of that 100 points, 20 points is your quiz that you'll take. So that incorporates into that. Then you have your pre-lab notebook and your post-lab notebook. That's 10 points.

Then there are 5 points which are noted as discretionary points for the TA. And that would be like does this student show up on time. Does the student clean up their area at the end of the lab? Does the student wear their safety glasses or do they walk around with the glasses up in the air? So that's important. And then your lab report, either written or oral, would be 65 points.

I'll show you this is the course textbook. This is the book that we recommend that you get. It's Mohrig. and it's *Laboratory Techniques in Organic Chemistry.* Very good book. It has chapters on all of the instrumentation and a lot of the techniques that you'll be actually using in the course. Well worth to buy this book. The other book that is not required but it's on reserve and we have copies in the lab is this ACS style guide. This will help you in terms of writing up your lab reports, writing up the reference section, knowing how correctly to put things together.

Attendance. Attendance is not mandatory for this class. But there is an attendance sheet going around. And each lecture day we will send it around. If you don't attend lecture, your grade isn't going to be penalized. But if you do attend all of the lectures, at the end of the semester, if your grade somehow is within a half a point of a higher grade, 89.5, technically you'd get a B plus, we'll look at the lecture attendance and that grade could be pushed up to an A minus. So that's how the lecture attendance works into this system. And if you have any questions as I'm going along, just ask.

So to get a passing grade in 5.310, you need to turn in the four written reports and you need to deliver the oral report. There are some penalties. So for a late lab, we use three times n minus 1 plus 2, where n equals the number of days the lab is late. Also, with each lab, you need to attach a cover sheet to your written lab. No cover sheet is minus 2 points.

There are also some late points on the oral report. If you're late for an oral report, it's minus five points. If it has to be rescheduled, it's minus 10 points, just so you're aware of the late points. You don't want to use these if you don't have to. You really want to try to turn your labs in on time. And that two points or five points could make a big difference at the end.

So this is the hard copy of the course manual. And you'll be allowed to bring this in with you to lab. You don't have to write up the pre-lab step by step that you're going to do. You can bring this in and follow it. So we're saving you a couple hours a week here. I hope you appreciate that. Students used to have to write the pre-lab out step by step in their own words. So this is a big time saver for you. I want to keep this course under that 12 credit limits.

You will need a lab notebook. And the lab notebooks are available either at the MIT Coop or they have them at the VWR stock room. And they're around $15. And the notebook should be like 100 duplicate pages with carbonless paper because what's going to happen is each day you go to lab, the TA will initial your pre-lab.

And then at the end of lab, you'll go to the TA with your notebook. And the TA will initial each page of your post-lab notes. Then you'll tear them all out and hand them to your TA. You keep the original. We get the copy. The reason for that is when it comes down to the final lab report, you cannot have anything in the lab report that's not in your post-lab notes in your notebook.

So let's just take a quick look and see. For the pre-lab, this is pretty simple. You don't have to write out the whole procedure, but you do need to have your title, date, the name of the experiment, an introduction, a couple of sentences what this experiment is about, what you hope to get out of it, maybe a couple of sentences on safety issues that you spotted in the experiment, and then any pre-lab equations you think you'll need.

The first pre-lab is due Monday and Tuesday next week. That's when the lab actually will commence. Tables are very good to put in your lab notebook and in your lab reports as well as drawings that might help you to actually visualize what you're setting up.

For the post-lab, this is probably the most detailed part because you've got to write everything down that you're doing in lab, all your observations, everything that's happening. When you're over at the distillation, you're going to record the temperature that the distillate started to come over. You're going to record the drops per minute that's coming over. All of these notes go into your lab book while you're working in the lab.

So let me show you a couple examples of lab notebooks, what students have done. This is one example where a student had-- sorry-- where a student had put their pre-lab notes on one side and left the other side for their post-lab. This isn't necessarily the best way to do it because you don't know how much space to leave for your post-lab. So another way to do it would be just to write out your pre-lab on one page, and then stop, and then start your post-lab on the next page.

The other thing that comes up is these are four to five day labs. So when you read the whole experiment, one way to do it is write your lab up for the whole experiment all in one time. Then you don't have to write it up each time. That works for a lot of students. But we only require you to write the pre-lab for the day that you're actually doing.

So I want to talk just a bit about some questions that come up a lot, like what is the stability of my chemicals. You're going to be working with some very air sensitive chemicals. So you might go over to the balance area and mass out your chemical for the first lab. You have iron chloride tetrahydrate. You mass that out but then you walk away. If you don't put the cover on the chemical, the green chemical will turn brown. And it's not going to be any good for the other students who are doing the lab because the iron gets oxidized. And you need iron-2 to do the experiment. So be aware of that.

And then how do I get what I need from a stock solution? So you're going to see chemicals like this labeled stock solutions for the lab. The one thing you don't want to do is open this up and go into a stock solution with a dirty pipette, because if you do that, you'll contaminate the solution for the whole class.

And some of the experiments are really quantitative and very sensitive, especially the Charles River where we're looking at the phosphate levels. So what you want to do is you want to make sure that-- and the TA should do this-- have these chemicals poured out in labeled beakers so that they're ready for the students to actually go into and draw out what they need. If you don't see that, always ask your TA. Never go directly into the stock solution.

And then the order in which you add chemicals is very important. You always want to-- you always want to go from the concentrated to the less concentrated. You would never want to take water and add it to acid because it would splash right back in your face. You always want to go the reverse. Add the acid to the water. Concentrated to less concentrated. And if you spill chemicals while working, let us know. It's very important. Don't leave them.

A couple or few years ago, we had a class during IAP. And one of the freshmen spilled a half a bottle of urea on the floor and left it. And the TA was beside himself. He was saying who did this. Nobody would own up to it. But we just happened to be filming this class.

And there is a video online that you can go watch. And you can see-- you'll know who it is when you watch the video. So you always want to let us know. And we always want to clean up if there is a spill. And if it's a spill, you have to let us know right away. We have to determine how bad it is so we don't have to evacuate the lab or something.

And then if you get chemicals on yourself, you know you've got to let us know because chemicals on yourself, we can take care of it right on the spot, get you washed off. If we have to, we'll walk you over to MIT Health to have them look at it.

And chemical waste. There are a lot of different kinds of waste containers in the lab. We've got boxes here for glass and plastic. And you've got to look at the box before you throw something in. Broken glass would go in the glass box. Plastic pipette tips go in the plastic box. And make sure that you empty them of your chemical first into the waste container before you throw the pipette's tips into the box. There are bottles for liquid waste.

And everything is labeled. You can see the red labels here. A couple of things you should know. Don't pour into the top of this. This is a lid so that it actually opens up and then you pour it in. And then you always have to close this container after you've added your waste. If you leave a waste container open during an active lab and we're inspected, MIT can be fined thousands of dollars.

So you've got to keep the waste containers closed. The other thing is you've got to be aware of what you're putting in. So read the container. Make sure it's the chemical that you're using that's going in. You never want to put acetone in to anything except a bottle that says acetone, because we're going to be using hydrogen peroxide in this class.

And hydrogen peroxide and acetone and you have an explosion. So what you're making is you're actually creating these acetone peroxy compounds. This is the dimer. It's called acetone peroxide explosive apex. And then there's also a trimer. And this is the triacetone peroxide.

So what happens with these is they form a white crystalline powder. And it smells like bleach. And when that forms, just any movement could trigger it. This is the same stuff that the shoe bomber had in his shoe if some of you remember 10 years ago on the plane. And so it's very frightening. So you have to be mindful of what you're putting in the containers. The acetone we're going to recycle. So it will have containers just for acetone. And that's where you're going to dump it.

The other thing you want to be aware of is nitric acid. We're using nitric acid in the Charles River lab. You don't want to mix this with any kind of organic solvents. If we put this, say, with ethanol, then you're making this C2H5 ethyl nitrate.

And this is also a primary explosive. The first thing that happens is you'll see orange smoke billowing out. And then you'll hear this whining noise. And it gets louder and louder. And then the hood goes. The ceiling goes. So if you see smoke or you hear noises, get away from the hood. But don't put nitric acid with anything except in the container that says nitric acid.

There are also some containers for solid waste by the scales. So as you're massing your chemicals out, if you have a little bit left over, they go in the can with you with your weigh boats. Don't put gloves into the cans. Gloves can go in the trash.

We have a box for needles here, which is great. And don't put needles in the trash, because the cleaners grab those trash bags at night and they could get poked. And that would not be good. So the needles, we're going to try to count them out. And the TA will be judicious in coming around with the needle box and collect them at the end.

Calibration of melting point. I just want to show you one thing here. If you go to the melting point and you take a melting point of your sample, an uncalibrated melting temperature might be 64 to 66 degrees. Once it's calibrated, you're up to 79 to 80.9 degrees. So we have four standards. And each standard has a range where it starts to melt and ends melting.

So you put your standard in. Then you look through the scope. And you record your observed where it's melting, when it started, when it stopped. And you have two points for each standard. So you can do a linear regression and draw a straight line and get an equation for the line. And then every time that you use that melting temperature, you can calculate-- you put in your experimental and calculate what it should be from the equation.

So we've got we've got a couple of minutes left. And this is a chemistry class. So I'd like to do a demonstration just to end this class. And I need a volunteer. Yes. Come on. And what is your name?

AUDIENCE: Autumn.

PROFESSOR: Autumn. OK, Autumn. So Autumn, I've got a cup here and some water. So I'm going to pour some water into the cup. And you tell me when to stop. OK?

AUDIENCE: Stop.

PROFESSOR: OK. So what I'm going to do is I'm going to cover this up. OK. And then I'm going to carefully turn this over. So far so good, right? You know where I'm going with this, Autumn? I'm going to put it on your head. Face your fellow students. And we'll go up here very gently. And there we go. Now I'm going to let you hold it, Autumn, because I don't want to be responsible. OK. OK. You OK so far?

AUDIENCE: Yep.

PROFESSOR: OK. All right. Autumn, what does this say?

AUDIENCE: Do not remove this card.

PROFESSOR: Whoops. OK. Let me take this off from Autumn.

AUDIENCE: What's on my head?

PROFESSOR: What happened to the water, Autumn?

AUDIENCE: Is there something inside that absorbed it?

PROFESSOR: She said is there something inside that absorbed it? OK. Let's see what we got here. We made a polymer.

AUDIENCE: Cool.

PROFESSOR: So unbeknownst to Autumn, I had a little bit of powder in her cup. And when I put the water in, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1.

AUDIENCE: What kind of polymer is it?

PROFESSOR: I knew you were going to ask that. What kind of polymer is this?

AUDIENCE: I'm Course three.

PROFESSOR: OK. So you'll all know this. Hold that for a minute, Autumn. This is the diaper polymer. This is sodium polyacrylate. And I actually took one of these diapers. And I cut it open. And I got 4 grams of sodium polyacrylate out of the diaper.

So this is how they work. These polymers, you can see this polyacrylate is a monomer repeating unit. And what happens is if you look inside, it has a lot of sodiums. But when we put the water around it, it starts to send sodium out and pull water in by osmosis to balance the sodium atoms. So all of a sudden it swells up. And you've got this system here.

Now we're going to do a little experiment. We're going to take this and put those on now. OK. So I'm going to take this and put it into a little baggy. Hold that bag.

AUDIENCE: Add salt [INAUDIBLE].

PROFESSOR: I'm going to add some salt to this. And now we're doing the reverse of what we just did. We had added water to the polymer before but now we're putting salt in. So just zip that bag up. And this is the fun part, Autumn. You get to squish it around.

So now there are sodium ions on the outside of the polymer. And it's panicking. It's starting to pull them in and send some of the water back out. So the polymer is actually going back to a liquid. So that's how this works. Great. Give her a hand. She did a great job. Thank you so much, Autumn.

Well, thank you all. And the next lecture is Tuesday. Don't forget to go to the safety lecture. And that is downstairs, two flights down.