Demos: Making Science Fun!

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Part A:

About Demos

About Demos

History

Traditional science classes often extinguish young peoples' innate enthusiasm for the natural world by stressing rote memorization and factual recall rather than creative thinking and hands-on discovery. When he arrived in New Haven in the fall of 1986, Yale student Geoff Laff wanted to show New Haven elementary students that science could be both fun and accessible for everyone. He designed an hour-long presentation in which Yale undergraduates used visually striking demonstrations to illustrate basic scientific principles. Laff borrowed glassware, found some chemicals, and asked for help from established community groups to arrange funding, scheduling, and transportation. Demos was born in the spring of 1987.

By showing students that a seemingly dry and difficult subject like science could be fun, he hoped to offer students at least one reason to "stick it out." Elementary school students who enjoyed the presentations would, he hoped, take advantage of future opportunities to study science at the secondary and post-secondary levels. Like a movie preview, Demos science shows were meant to entice students to come back for more.

What began as a two-person act offering about five demonstrations per semester has evolved into an organization with more than 70 active volunteers visiting eight schools weekly. And the act is back, too, now called Demos Assemblies. Demos is always expanding, continually adding new demonstrations and new experiments.

What is “Demos”… or is it “DEMOS”?

Demos originally went by the name “DEMOS”, which stood for “Dynamic Education Marvels of Science.” After more than a decade, the original meaning of the “DEMOS” name was forgotten, and the name was changed to its present-day form, “Demos”, which is simply short for “demonstrations”.

Praise for Demos

Demos has won the praise of students, teachers, Yale volunteers and professors, and even Nobel Laureates. Take a look at some praise for our Demos Assembly program:

"Proof that learning science is fabulous fun!"
Leon Lederman, Physics Nobel Laureate

"We have had many assemblies over the years. Your program was one of the best I've seen in 15 years of teaching! Keep up the great work and PLEASE COME AGAIN! (Can't you make it a few times a year?) :)" [sic]

3rd Grade Teacher, Beaupre Elementary School, Aurora, IL

"We loved it. Come back next year!"

4th Grade Teacher, Vincent Mauro Elementary School, New Haven, CT

"It made the kids so excited about science."

2nd Grade Teacher, D.H. Ferrara School, East Haven, CT

"Great job and keep it up! :)"

5th Grade Teacher, Columbus School, New Haven, CT

"Why can't school be like this?"

Middle School student, after seeing Demos at New Haven's MathCounts competition.

Demos: Making Science Fun!

Demos Programs

Weekly Classroom Program

The weekly classroom program creates an interactive learning laboratory in a 3rd to 5th grade elementary school classroom. Demos volunteers work to spark students' interest in science and to guide them through basic scientific principles by leading hands-on activities. A typical visit might involve making slime, building cars, dissecting owl barf, using eggs to talk about bicycle helmet safety, or cleaning up an oil spill. Volunteers return to the same classroom for one hour each week of the semester, giving them a chance to develop a relationship with their students.

The curriculum is always interactive, usually involves building something, and covers a wide variety of subject areas – from physics and chemistry to biology, earth sciences and engineering! We design our curriculum with the purpose of giving students opportunities they might not have in the standard New Haven curriculum. We also ensure that each of our hour-long modules meets Connecticut curriculum standards.

Volunteer Involvement: 1 hour per week, plus roughly 15-30 minutes total travel time. Flexible scheduling.

For more information, contact: Chidi Akusobi (chidiebere.akusobi@yale.edu) and Scarlett Lee (scarlett.lee@yale.edu)

Assemblies

Demos Assemblies presents one-time, 45-minute presentations to large groups of students (numbering ~200). The assembly format, while still interactive and education, allows Demos volunteers to present large-scale demonstrations that might not fit into a typical classroom. And our materials aren't typical, either. We use everything from liquid nitrogen, dry ice and some pretty crazy chemicals to frozen bananas, flowers and diapers to show students the three states of matter and chemical reactions. The assembly program is designed for all students in grades K-5, and like the classroom program, meets Connecticut curriculum standards.

Volunteer Involvement: 2.0 hours per assembly, which are held roughly every three weeks typically on Fridays. Schedule varies, so the volunteer commitment is flexible.

For more information, contact: Lisa Pan (lisa.pan@yale.edu) and Kaitlin McLean (Kaitlin.mclean1@gmail.com)

Planetarium

Demos is the proud owner of a traveling, inflatable planetarium. Dubbed Starlab, the planetarium holds 27 small kids and allows them to learn about planets, stars, and galaxies in a fun interactive manner. The newly developed protocol is fun and exciting and is designed to teach the basics of astronomy to elementary aged students.

Volunteer involvement is similar to that of Assemblies. Starlab demonstrations will typically occur at Yale venues in addition to schools once every three weeks. Volunteer involvement is roughly 2.0 hours per demonstration.

For more information, contact: Sisira Gorthala (sisira.gorthala@yale.edu)

Communiversity Day

Demos encourages greater community and family involvement in science through Demos' involvement in the University's "Communiversity Day." Demos sets up a table alongside many other university groups and invites the community to take part in some of our favorite experiments.

Demos will send out more information as the date approaches in the spring.

Part B:

General Information

Demos: Making Science Fun!

Teaching Tips

Summary

Volunteering with Demos is a unique experience! Teaching a class of elementary school students is entirely different than giving a presentation to your advanced chemistry class. It might seem like a daunting task, but practice, as always, makes perfect. ANYONE can do it.

Here are a couple of tips to help you get started. This is a huge list, but most of the items are just “common sense” things.

> Keep in mind this is a just a *guide*. It is not comprehensive or exclusive. Be creative and use common sense! If you’ve found something that works well in your classroom, share it with other volunteers and with your school coordinator!

In General

In general, remember who you audience is, and what you’re trying to do. You’re goal is to teach some cool and fun science to elementary students. **You are not giving a lecture to graduate students** on “Novel Fluorescent Polymers as Sensory Materials for Above-Ground Detection of Chemical Signature Compounds in Nitroaromatic Explosives at Ultra-Trace Amounts.” (PS – Google search that, it’s an interesting paper.) So be exciting and interesting, and keep the science at the elementary level! And, don’t forget: you should have fun, too.

How to Talk About Science

There is a right way and a wrong way to talk about science with elementary students. **Basically, you should avoid fancy vocabulary and do a demonstration whenever possible.** While you would technically be correct if you said, “an object will remain at rest or in uniform motion until a force is exerted upon it,” you would also sound like a textbook. A much better way to demonstrate that same concept is to take a ball, set it on a table, and show that “it will sit still until something pushes or pulls on it!” Then, to demonstrate, push the ball off of the table.

In addition, there are right and wrong amounts of science to talk about with elementary students. It is important to tailor your explanations to you students’ level of understanding. Chances are it’s been a while since you’ve been in an elementary school so it will take some trial and error, but eventually you’ll figure out the appropriate amount of scientific content for your classroom. For example: When explaining why a balloon shrinks when cooled by liquid nitrogen, it might be appropriate to cover either the fact that colder gasses have lower pressure or that some of the gas is turning into a liquid. It’s probably only confusing to talk about both. Use the “learning outcomes” and “key concepts” from the protocol to help guide your explanation. Equations don’t fit into this sort of hands-on elementary school activity, either.

Not Your Average Science Class

Don’t stand at the front of the room and lecture. Walk around and help your students with their activity!

When you’re showing something to your students or talking to them, be sure to **ask lots of questions**. You may get some odd answers (i.e., “Connecticut” is one of the “three states of matter”), but it’s important to not discourage your students. Instead, help them work to the right answer (“Well, Connecticut is a state – but I’m actually wondering if anyone knows the three *states of matter*. Let me give you a hint. “Liquid” is one of them…”)

Scientific Method

The Demos protocols aren’t scripts, so you’ll have to fill in some of the blanks yourself. We strongly encourage you to **emphasize the scientific method** when talking with your students. This is particularly important early on in the semester. If you successfully frame the first experiment in terms of the scientific method you can refer back to it in subsequent weeks. Don’t be afraid to identify different steps of the scientific method in action as you progress through an activity.

Also, it is definitely encouraged to have students occasionally pull out a paper and pencil to write down observations, make charts, draw diagrams, etc.

Scientific Method (The steps are frequently combined or divided in a number of ways; this is meant to be a rather complete listing of the steps of the scientific method. It may be a good idea to ask your classroom teacher which particular formation of the method is used in his/her classroom.)

1. Observation
2. Hypothesis
3. Procedure (Materials & Methods)
4. Experiment
5. Results
6. Discussion / Conclusions

Dealing with Difficult Children

Occasionally you’ll have “difficult” children, who won’t want to go along with the activity, will try to talk over you, etc. Here are a few tips:

- Talk to the classroom teacher about how to handle misbehaving students. Or, if the teacher remains in the room, ask them to help you deal with them.
- Take control of the class early. Make sure they know that you are in charge.

- Sometimes classrooms have special “symbols” to encourage everyone to quiet down and return to their seat. (For example, some teachers raise three fingers, like a boy scout, and the class quiets down and follows suit.) If there is such a technique, note it and use it.
- If working in small groups, ask the students questions about the activity and the science to try and get them to actively participate. Perhaps suggest a secondary goal for the students (i.e., don’t just make the best bridge – make the best and lightest bridge.) This is especially helpful for know-it-alls. They will behave and learn more!
- While you don’t want to reward bad behavior, you can have a trouble-maker be your helper when you are showing a demonstration to the class.
- If anyone gets really out of hand (this is unlikely) you may have to ask them to not participate. This is especially important on days when chemicals or other materials that require supervision are involved.

Demos: Making Science Fun!

Safety Information

Safety in Elementary Schools: It is extremely important that Demos volunteers set a good example for elementary students by following safety precautions at all times – even those that may seem onerous or unnecessary. Elementary students will be quick to follow a volunteer who adheres to safety regulations and that can encourage safe practice for the rest of their lives. Remember, elementary students think that you are very, very cool. If anyone can make safety goggles stylish, it's you.

Orderly Classroom: Many potential hazards can be eliminated by a safe and orderly classroom. Before each experiment establish ground rules about acceptable behavior. For example, if an activity doesn't involve movement, ensure that students stay seated. Demos volunteers should familiarize themselves with the activity – the protocol and the materials – before entering the classroom so that they can focus their entire attention on their students. See the section of this guide titled "Teaching Tips".

Materials Safety: Demos will never give volunteers or students materials that are not suited for use in an elementary school. That said, **we will from time-to-time use materials that do necessitate direct supervision.** Read the section at the beginning of each protocol on safety. That section will identify specific safety concerns about material used in that week's activity. Most importantly, appropriate use of all materials should be discussed before they are distributed. Yale volunteers should themselves treat all materials with respect. Goggles and gloves should be worn when appropriate.

First Aid:

- In the event of any accident, remain calm, and notify all appropriate authorities, including school personnel and emergency services.
- In the case of a burn (or chemical burn) flush the affected area with cold water for a minimum of ten (10) minutes.
- In the case of a cut: *Be Careful! Do not touch the wound, or blood.* Rinse with cold water. Reduce bleeding by elevating and applying pressure on the area of the cut.

IN THE EVENT OF AN EMERGENCY OR INJURY:

Contact all appropriate authorities – including school personnel and emergency services (911).

Then contact Chidi Akusobi at (646) 812-5224 or Scarlett Lee at (972) 213-5409.

Frequently Asked Questions

In General

Q: This FAQ doesn’t answer my question!
A: Let us know! If you have any questions that this guide does not answer, please contact us and we’ll be happy to find you an answer!

Q: Why don’t you do _____ this way? It’d work better that way!
A: We’re constantly looking to improve Demos. If you have a suggestion on any aspect of the Demos program, let us know! Contact your school coordinator or Rachel and Ellie.

Schedule Conflicts

Q: What do I do if my partner can't make it one week?
A: **First, you should still go to your classroom!** Then, you have two options. You can choose to go by yourself, being conscious of some of the increased challenges of managing the lesson plan and classroom on your own. You can also ask a friend or suitemate to come along as a guest. It offers a great opportunity for others to experience Demos firsthand.

Q: What do I do if my partner and I both absolutely, positively can't make it one week?
A: If you know well in advance that you and your partner cannot make it, try to reschedule your Demos time with your teacher. In the case of more immediate conflicts (more than twenty-four hours in advance), contact your school coordinator who will try their best to make alternate arrangements. With last minute **emergencies (less than twenty-four hours in advance)**, contact the school directly and have them inform your teacher of your impending absence. If you cannot alert your school coordinator more than twenty-four hours before your absence, **you are responsible for contacting your school!** Always let your school coordinator know if you’ve had to miss a class.

Getting to the Classroom

Q: What do I do once I get to the school?
A: You will first need to go to your school’s front office. Although the front office is always located by the main entrance, it may involve a little bit of searching to find that front door. After entering, go to the school’s office and inform them that you are a volunteer with “Demos” and are going to be volunteering in Mr./Mrs. So-and-so’s classroom. They will then have you sign in. If you do not know where your classroom is, ask, and they will show you to your room.

Q: Why doesn't the school know I'm coming!?
A: The school *does* know that you're coming. But not everyone at the school knows that you're coming. The principal or lead teacher and your classroom teacher are expecting you – but the receptionist might not be. There's a lot going on in a school, so sometimes information about Demos isn't passed to the receptionist or other individuals in the schools. This is entirely normal and nothing at all to worry about.

Q: Do I go to the class if it is snowing?
A: **Yes!** You will receive a notice from your school coordinator whenever school does not meet or Demos is not meeting. **Always assume that the school is meeting.** If you'd like to double check for yourself, go to the New Haven Public Schools website (www.nhps.net) which will inform you of any delays or school closures due to weather. It is also prudent to plan on needing extra time getting to and from your school whether by foot, bus, or taxi. If it's snowing or raining, of course, feel free to take a taxi even if you usually walk.

Q: Where can I get a bus pass?
A: Your school coordinator can provide you with a bus pass. Each pass is good for 10 rides. Should you run out and be unable to reach your school coordinator, go to the Dwight Hall office during normal business hours and ask the administrative assistant, Maura, for one. She will have you write down your name and affiliation (Demos) and then give you a bus pass good for another 10 rides. There is no charge for the pass. If you run out of rides at any time during the year, just go back and ask for another one.

Q: What do I do if I miss my bus?
A: Please don't miss your bus! If you do, however, you may either walk if the school is close or call a cab (203-777-7777). In case of the latter, be sure to follow the instructions on the transportation page so that the ride is charged to Demos. Keep in mind that calling a cab is the last possible option. We discourage volunteers from taking taxis because it quickly becomes a strain on the budget.

Supplies

Q: Where/when do I pick up supplies?
A: The day that you will be visiting your classroom, you will need to go to Dwight Hall on Old Campus to pick up supplies. The entrance is a single door facing Old Campus. It's the entrance immediately to the left of the big chapel doors – not the entrance with a handicapped ramp. If it's especially early in the morning, or the night before your trip, you might need to use your ID to enter the building. There will be a staircase in front of you, go up the staircase and enter the room Demos room through the glass doors on your right. **Please take your designated bag only**. Remember to post your initials on our signup sheet. That way we know you are volunteering.

Q: Where do I return supplies?
A: In Dwight Hall, one of the storage crates will be marked "Return". **Please follow the instructions on the protocol about what to return and what to throw out!** Do not put perishable items such as opened bags of food or milk back into these crates.

Q: What do I do if supplies are not ready to pick up?
A: Your supplies should always be ready to pick up for your classroom beginning the morning of your designated day. Contact your school coordinator if they are not available. If he or she is unreachable, call either Chidi or Scarlett In a catastrophic (and extremely unlikely) case, you may need to inform your school that you will be absent.

Q: What do I do if certain supplies are missing?
A: **Please check your bag before leaving Dwight Hall.** We pack a lot of bags each week, and occasionally we miss a thing or two. There is a bin of extra supplies next to your bag, take as many as you need. If extras are not available, call your school coordinator to see if last minute arrangements can be made. If you are already at your school, do your best to follow the protocol without the missing supplies. This may include either altering the activity or even skipping certain sections.

Q: Will I ever have to purchase supplies myself?
A: Yes. There will probably be one or two occasions when an activity will require something like ice, which we definitely cannot keep in our Dwight Hall office. In this case, your school coordinator will notify you by email in advance with instructions for obtaining the supplies that you need. This is another reason that it's very important to **read the protocols before going to your school.** In the very rare cases that we will ask you to purchase supplies, keep the receipt, and you will be fully refunded for the cost.

In the Classroom

Q: What do I do if don't know the answer to a student's question?
A: Do your best to explain what you know, but don't be afraid to say you don't know. It is nearly impossible to be able to recall answers to every conceivable question considering the breadth of topics covered in Demos. It is often nice to be able to come back the next week having done some research and answer the student's previously unanswered question. Remember, though, that you're talking to elementary students – you'll want to try and simply the answer that you found so that your students will understand it!

Q: What do I do if I don't understand a part of the protocol or the science behind it?
A: Contact your school coordinator with any specific questions or concerns. He or she will either answer the question or find an answer for you. You can also do some research on your own. There is a wealth of information on the web; Wikipedia is a good place to start for most topics.

Q: Can the students eat the food used in some experiments?
A: **NO.** Not all food provided in your materials bag is safe to eat. The protocol would explicitly state if a food item can be consumed. Often, it is very old or has not been handled properly for consumption. Certainly, in many cases the food will be safe to eat, but the protocol will always indicate when food is safe to eat. (For example, the spring semester ice cream protocol has students make ice cream!) When food is indicated as safe for consumption, **run it by the teacher first** and then use your own discretion in determining whether to allow students to eat! **Be sure to inquire about any food allergies including wheat, dairy, and peanut.**

Q: Can I bring candy or other rewards to the classroom for the students?
A: In general, this isn't a problem, but **be sure to run it by your teacher first**. Again, be aware of any potential food allergies (a good rule is to simply avoid candy with nuts) and the amount of candy you give out.

Q: Can the students take various experimental materials home?
A: Certain supplies should be returned to Demos as indicated on the protocol. Some materials that are clearly perishable or messy should probably just be thrown out. With any remaining materials use your discretion in allowing students to take them home. Keep in mind the issue of fairness such as the ability for each student individually to take something home and always consult with your classroom teacher before permitting students to take materials home.

Further Involvement in Demos

Q: How can I get more involved with Demos?
A: Consider joining the Assemblies or Starlab program, volunteering for Communiversity Day, or applying for the Demos board in the spring. For further information on any of these opportunities, watch for emails about these opportunities or contact your school coordinator. Also consider coming up with your own ideas for activities with your students.

Q: Where do your protocols come from? What do I do if I have a good idea for an experiment or demonstration?
A: In general, the protocols are a combination of time-tested hands-on science classics (silly putty and ice cream, for example) and new ideas produced by Demos volunteers and board members. Each semester Demos hosts a protocol planning event, where we begin work on original ideas for next semester. If you want to be involved, or have an idea for a specific activity this semester that's great! Keep an eye out for announcements about the protocol meeting, or send us an email with your idea. We'll help you develop it, or develop it for you, if you'd rather.

Q: Why don't you have _____? I LOVED that when I was in elementary school!
A: We're always willing to expand our collection of materials and protocols. Is there something that you know about, or that you did in elementary school that you'd like to share with a classroom that you think Demos should have? Let us know!

Part C:

Resources

Demos: Making Science Fun!

Contact Information: Demos Board

Who to contact?

When you have a question about anything Demos-related, the first person you contact should be your "School Coordinator." They will be the most familiar with you and your classroom. If it's urgent – you need to have a question answered before you're expected in a classroom, or if you're ill and cannot make it – please feel free to contact your school coordinator via their cell phone.

If you cannot reach your school coordinator, feel free to contact either Rachel or Ellie at any time, with any question.

Demos Contact List

Name	**Email**	**Cell Phone**
Coordinators		
Chidi Akusobi	chidiebere.akusobi@yale.edu	(646) 812 5224
Scarlett Lee	scarlett.lee@yale.edu	(972) 213 5409
School Coordinators		
Liz Asai	Elizabeth.asai@yale.edu	(703) 300-0700
Chris Cho	chris.cho@yale.edu	(909)-800-5367
Gennifer Tsoi	gennifer.tsoi@yale.edu	(917) 478-8000
Joyce Cheng	joyce.cheng@yale.edu	(858) 539-6176
Clarence Cheng	clarence.cheng@yale.edu	(320) 267-2438
Byron Edwards	Byron.edwards@yale.edu	(201) 835-3111
StarLab Coordinator		
Sisira Gorthala	sisisra.gorthala@yale.edu	(828) 713-8059
Webmaster		
Sherry Zhou	xiao-qiao.zhou@yale.edu	(336) 870-6490
Assemblies Coordinator		
Lisa Pan	lisa.pan@yale.edu	(636) 346-0766
Kaitlin McLean	Kaitlin.mclean1@gmail.edu	(608) 333-3337
Operations Coordinator		
Tomoki Kimura	tomoki.kimura@yale.edu	(201) 233-7123
Bernie Kuan	bernie.kuan@yale.edu	(626) 283-8987
Inventory Coordinator		
Linda Li	linda.li@yale.edu	
Yuan Kang	yuan.kang@yale.edu	(978) 394-1652

School Coordinator Assignments:

Elizabeth Asai	Fair Haven
Chris Cho	Augusta Lewis Troup School
Gennifer Tsoi	Worthington Hooker Celantano Museum Academy
Joyce Cheng	East Rock Global Magnet School Conte West Hills Magnet School
Clarence Cheng	John C. Daniels Bernard Environmental Magnet
Byron Edwards	Lincoln-Bassett

Contact Information: Schools

When should I contact a school?
In general, as a Demos volunteer you will not need to contact your school's front office. There are a few exceptions however:

- A last minute **emergency** such that you cannot make it to the school and do not have time to arrange a substitute.
- A last minute **emergency** and you are unable to get in contact with your school coordinator.

Therefore, if one of those situations applies to you, give your school a call.

How to contact your school:
Be sure to clearly identify yourself as with the Yale Demos program – be prepared to explain that you visit Mr./Ms. So-and-so's classroom every week at such and such a time. In all likelihood, Mr./Ms. So-and-so will be teaching and unable to take your call, so leave the appropriate message with the receptionist. School hours are generally 8am to 4pm.

Demos School List

School (Grades)	Address	Front Office
Fair Haven School	164 Grand Ave.	(203) 691-2600
Augusta Lewis Troup School	259 Edgewood Ave.	(203) 691-3000
Bernard Environmental Magnet	170 Derby Ave.	(203) 691-3500
East Rock Global Magnet School	133 Nash St.	(203) 946-8867
Worthington Hooker	180 Canner St.	(203) 946-8654
John C. Daniels School	569 Congress Ave.	(203) 691-3600
Lincoln-Bassett School	130 Bassett St.	(203) 946-8839
Celanto Museum Academy	400 Canner St.	(203) 691-3400
Conte/West Hills Magnet School	511 Chapel St.	(203) 946-8279

All schools belong to the New Haven Public Schools. All schools are in New Haven, CT. More information at: www.nhps.net

Transportation Information

In General

Being on time is very important! Your and our reputations with the local elementary schools depend on it!

School Coordinators will inform volunteers about available methods of transportation to the local elementary schools. Volunteers will have three options: walking, taking a New Haven city bus or taking a cab. Demos will cover the costs of busses and cabs. We encourage you to walk whenever possible, since it is the most reliable means of transportation. If it's pouring rain or freezing cold you are welcome to take a cab even if your school is nearby.

Cabs

Demos has an account with Metro Taxi in New Haven. To use the account, you **must** call their dispatcher for a cab – you cannot simply hail one on the street. The Metro Taxi phone number is (203) 777-7777.

When you speak to dispatcher tell them that you'd like to pay for the ride with an account. The account number is ________. The authorizing name is __________________________. (The name and number will be provided by your school coordinator. Please do not share this information. *Demos is funded by grants from nonprofit organizations and donations from individuals. It is highly inappropriate to use these taxi codes for anything other than Demos rides. Violators will be subject to discipline from the University*.)

You can call for cabs up to a day early, but it is best to call again roughly 5 to 15 minutes before you need to leave to confirm that you have a taxi coming for you. Be sure to book a return reservation! The dispatcher and the drivers will want to know the address of your destination; they're listed in the School Contact information section and in the school-by-school directions below. The cab driver will give you a receipt to sign. fill in the correct cost of the trip (as indicated by the meter) and add a 10-15% tip.

Bus Passes

Your school coordinator will provide you with bus passes and instructions on how to use the New Haven bus system. They can also be picked up from the Dwight Hall office. Tell them you're a Demos volunteer. For more information on the New Haven bus system, including bus timetables, visit http://www.cttransit.com/content/routesNewHaven.asp

Directions to Barnard Environmental Magnet School – 170 Derby Ave.

Your school coordinator, Clarence Cheng, will provide directions to Barnard Environmental Magnet School.

Directions to Daniels - 569 Congress Ave

We encourage you to walk. Estimated walking time: 15 minutes

Walk straight down College Street
Cross Crown Street, George Street, and walk over the bridge.
College Street curves right, and becomes Congress Avenue
Stay on Congress Avenue for about 5 blocks.
You will cross Howard Avenue, Vernon Street, Ward, Street and Asylum Street.
John C. Daniels Elementary is on the right hand side of Congress Avenue, near the intersection of Hallock Street and Congress Avenue. It is a new building.

Directions to Augusta Lewis Troup School -259 Edgewood Ave.

Your school coordinator, Chris Cho, will provide directions for getting to Augusta Lewis Troup School.

Directions to East Rock Global Magnet School -133 Nash St.

Your school coordinator, Joyce Cheng, will provide directions for getting to East Rock Global Magnet School

Directions to Fair Haven School – 164 Grand Ave.

Your school coordinator, Liz Asai, will provide directions for getting to Fair Haven School

Directions to Lincoln-Bassett – 130 Bassett St

Please take a bus or a cab to Lincoln-Bassett.

Any of the D busses marked "DIXWELL AV" will get you to Lincoln Bassett.

The bus leaves from the Chapel street at the intersection of Chapel St. and Church St on the New Haven Green (that's near Blockbuster) roughly every 10 to 15 minutes.

You can get off at Bassett St. and Dixwell Ave. Turn right onto Bassett St. The school is at the intersection of Butler St. and Bassett St.

Directions to Conte/West Hills- 511 Chapel Street
Your school coordinator, Joyce Cheng, will provide directions for getting to Cold Springs School.

Directions to Celantano Museum Academy – 400 Canner St.

Your school coordinator, Gennifer Tsoi, will provide directions for getting to Celantano Museum Academy

Directions to Worthington Hooker School – 180 Canner St
Your school coordinator, Gennifer Tsoi, will provide directions for getting to Worthington Hooker School.

Part D:

2009 Fall Semester Schedule and Protocols

Demos: Making Science Fun!

2010 Fall Semester Protocol Schedule

<u>Physics Unit</u>

Week 1: **Sept. 20-24**

Floating Egg

Using the scientific method to figure out why eggs float

Week 2: **Sept. 27-Oct. 1**

Egg in a Bottle

Learning how temperature and pressure sucks in an egg into a bottle

Week 3: **Oct. 4-8**

Cloud in a Bottle

Learning how clouds form

<u>Chemistry Unit</u>

Week 4: **Oct. 11-15**

Magic Solutions

Learning about solvents, solutes, and solutions

Week 5: **Oct. 18-22**

Invisible Ink

Learning about chemical reactions by using invisible ink

Week 6: **Oct. 25-29**

Slime

A little mysterious chemistry before Halloween

Week 7: **Nov. 2-6**

Power of Iron

Learning about the properties of magnetism and iron

<u>Biology Unit</u>

Week 8: **Nov. 8-12 (No school on Thursday)**

Extremophiles

Learning how organisms adapt to extreme conditions

Week 9: **Nov. 15-19**

Plant Biology

Understanding the various structures of a plant

Week 10: **Nov. 29- Dec. 3**

Owl Pellet

Dissecting a pellet to learn about animal anatomy

Demos: Making Science Fun!

Weekly Protocols

Summary

What follows are the weekly protocols, which contain all of the information that you will need to perform a hands-on science activity with the students in your elementary school classroom. **Volunteers (you) should read protocols BEFORE arriving at the classroom**, so that full attention can be devoted to the students. Each protocol includes:

Learning Outcomes: What students should be able to take away from the activity at the end of the day. This might help you to identify the key points of the activity.

Safety Considerations: Safety information specific to a given activity. For general information on safety, please see the section of this binder titled “Safety Information”.

CT Science Standards: Information summarizing which of the CT science standards are addressed by a specific protocol. This ensures that the activities that Demos presents are productive for both students and teachers.

Materials: A list of materials needed for a specific protocol and quantities necessary per classroom. The items and quantities listed might vary slightly from what Demos will provide, so be prepared to do a little improvisation.

Procedure: A step-by-step procedure. For each section, a *key concept* is identified, and the *procedure and talking points* are discussed. Each section has an *estimated time* which should be used as a guide to guarantee that the activity is finished in the allotted time.

Clean Up: Materials are divided into *Throw Out* and *Bring Back* categories. Please follow the instructions so that reusable materials – as indicated by this section – are kept and non-reusable materials are discarded. Be sure to allow adequate time for clean up.

Extras: The procedure and clean up sections are designed to fill the allotted time with the classroom, but occasionally activities run quickly. This section provides suggestions for extra activities to do with students to fill excess time.

Background: This section contains background science information suitable for Yale students of all majors. The information is incomplete, but designed so that you are able to provide background to elementary students and answer questions. **It is NOT designed to be read verbatim to elementary students.**

Physics Unit

"The observer, when he seems to himself to be observing a stone, is really, if **physics** is to be believed, observing the effects of the stone upon himself."

-Bertrand Russell

Week 1: The Floating Egg

Objectives: To understand the physical property of density and how it can be affected

Safety Considerations: Please advise the students to handle the eggs very carefully to prevent them from cracking

CT Science Standards:

Standard	Definition	Implementation
3.1	Materials have properties that can be identified and described through the use of simple tests.	Students will test the different densities of solutions using a raw egg.
3.1.B1	Sort and classify materials based on properties such as dissolving in water, sinking and floating, conducting heat, and attracting to magnets.	Students observe the physical properties of density by floating/sinking eggs in a solution of water with different solutes.

Materials:

Item	Per group (5 students)	Per classroom*
Eggs	1	5
Kosher Salt**	4 tablespoons	20 tablespoons
Sugar	4 tablespoons	20 tablespoons
Liquid soap	1 small bottle	5 small bottles
Cooking oil	1 small bottle	5 small bottles
Plastic spoon	1	5
Transparent plastic cup	4	20

*For a 25 student classroom
**Note: It is not required that Kosher salt is used, but it will ensure that the salt-water solution will be completely transparent/clear.

Procedure:
<u>Part 1: (Discussing Density)</u>
Time for this section: 10 minutes
Key Concept: Density, Historical anecdote

Procedure:
1. Discuss and define density (mass per unit volume i.e. g/ml). Describe how density is a physical property of matter (so different materials, elements, and compounds will have varying densities). Ask students if they can think of a material that is very dense? One that isn't very dense?
2. Share the story below to better elucidate this point:

How Archimedes First Used Density[1]

"Sometime around 250 BC, the Greek mathematician Archimedes was given the task of determining whether a craftsman had defrauded the King of Syracuse by replacing some of the gold in the King's crown with silver. Archimedes thought about the problem while relaxing in a bathing pool. As he entered the pool, he noticed that water spilled over the sides of the pool. Archimedes had a moment of epiphany. He realized that the amount of water that spilled was equal in volume to the space that his body occupied. This fact suddenly provided him with a method for differentiating a mixed silver and gold crown from a pure gold crown. Because a measure of silver occupies more space than an equivalent measure of gold, Archimedes placed the craftsman's crown and a pure gold crown of equivalent mass in two tubs of water. He found that more water spilled over the sides of the tub when the craftsman's crown was submerged. It turned out that the craftsman had been defrauding the King! Legend has it that Archimedes was so excited about his discovery that he ran naked through the streets of Sicily shouting "Eureka! Eureka!" (the Greek word for "I have found it!")."

Part 2: (To Sink or Not to Sink)

Time for this section: 30 minutes

Key Concept: Density

Procedure:

Before starting the experiment, explain to the students what the concept of an experiment is. Briefly describe the main points of the scientific method (hypothesis, observation, and conclusion) and state that we'll be using this method to analyze our experiments for the rest of the semester.

1. Split the group into 5 groups of 5
2. Give each group 4 plastic cups that are all half full of tap water.
3. Place an egg in one plastic cup and see if it floats (The egg should sink to the bottom of the container).
4. Remove the egg from the cup (be careful not to spill the water).
5. Now add several tablespoons of salt (without stirring) into ONE plastic cup (we will use the other 3 for other solutes)
6. Before dropping the egg back into the cup, ask the students what they hypothesize will happen (will the egg sink or float?). The egg should sink again to the bottom of the container.
7. Now stir the solution of salt water thoroughly with a plastic spoon. Ask the class again to hypothesize what will happen.
8. Place the egg back into the cup (this time the egg should float). If the egg fails to float, go around the class and give each group more salt water to mix into the solution (though 4 tablespoons of salt per cup should be enough to keep the egg afloat).
9. Ask the class why the egg floated when you mixed the salt water but failed to float when the salt was merely sitting on the bottom of the cup. (Because adding salt and mixing it into solution increases the density of the solution, the now relatively less dense egg will float).
10. Repeat this same process with the other 3 solutes (sugar, liquid soap, and cooking oil). Have the students make a table (below) and make them fill it in as they continue the experiment.

	Unmixed	Mixed
Water		
Salt + Water		
Sugar (4 tablespoons) + Water		
Liquid soap (4 tablespoons) + Water		
Cooking oil (4 tablespoons) + Water		

11. After the students have tested the various solutions, discuss the different densities that each solution has. Ask the students to determine which solution they think is most dense and why. (Note that the more solute you put into the solution – i.e. the more mg of solid in a given ml of volume – the more dense it will be). In order to elucidate this point, have the students weigh the various cups by holding them. A cup half full of tap water will actually feel lighter than any other mixed solution; and therefore, plain tap water will be less dense.

Clean-up:
Time for section: 5 minutes
Throw Out: Used salt, sugar, liquid soap, cooking oil, and spoons.
Bring Back: Eggs, plastic cups, and all unused materials (salt, sugar, liquid soap, cooking oil, and spoons)

Enrichment:
(Activities if there is extra time or for older students)

What about Huge Steel Ships? Why Do They Float?[1]
"Large ships have a tremendous amount of space in them that is filled with air (think about it: cabins, movie theaters, onboard casinos, etc.). While steel is denser than water, air is less dense. Metal ships can float because their total density is less than that of the water that they float on. When the metal hull of a ship is breached, like when the *Titanic* struck an iceberg, water rushes in and replaces the air in the ship's hull. As a result, the total density of the ship changes and causes the ship to sink."

What about Submarines? How Do They Sink?[1]
"A submarine has a constant volume but it can vary its mass by taking in water into its ballast tanks. When water is taken in to the ballast tanks, the mass (and thus density) of the submarine increases and the submarine attains negative buoyancy that allows it to submerge into the ocean depths. Conversely, when water is released from the ballast tanks the vessel's density decreases allowing it to surface."

Background:
What are the components of an egg?[2]
The reason that eggs do not float in normal tap water is because they are very dense. Eggs are made up of a $CaCO_3$ shell, 40 different proteins that make up the albumen, and iron, vitamin A, vitamin D, phosphorus, calcium, thiamine, and riboflavin in the yolk.

Density Review[1]

"Archimedes had used the concept of density to expose the fraud. Density is a physical property of matter that expresses a relationship of mass to volume. The more mass an object contains in a given space, the denser it is. It is important to remember, though, that this relationship is not just about how closely packed together the atoms of an element or molecules of a compound are. Density is also affected by the atomic mass of an element or compound. Since different substances have different densities, density measurements are a useful means for identifying substances.

Density = Mass/Volume

Density is an intensive property of matter that is defined as the ratio of an object's mass to its volume. Mass is the amount of matter contained in an object and is commonly measured in units of grams (g). Volume is the amount of space taken up by a quantity of matter and is commonly expressed in cubic centimeters (cm^3) or in milliliters (ml) ($1cm^3 = 1$ ml). Therefore, common units used to express density are grams per milliliters (g/ml) and grams per cubic centimeter (g/cm^3).

Density can sometimes be confused in our minds with weight because the denser of two, equal-volume objects will be heavier. Remember, though, that it is the relationship between mass and volume that determines density and not volume or mass alone, or even how closely packed the atoms or molecules are. Look at the table below for examples of the densities of common substances."

Sources:

[1]http://www.visionlearning.com/library/module_viewer.php?mid=37
[2]http://www.exploratorium.edu/cooking/eggs/eggcomposition.html
[3]http://pbskids.org/zoom/activities/sci/makeaneggfloat.html

Week 2: Egg in the Bottle

Objectives: Students will learn about temperature and pressure and how they relate to each other.

Safety Considerations: Advise students not to drink the tap water and rubbing alcohol mixture. Take extra precaution with fire. Be careful not to choke on the egg when popping it out of the bottle.

CT Science Standards:

Standard	Definition	Implementation
B INQ.1	Make observations and ask questions about objects, organisms and the environment.	Students learn how temperature is measured and how it relates to pressure.
4.1	The position and motion of objects can be changed by pushing or pulling.	Students observe the effects of temperature and pressure on stationary objects.

Materials: Part 1

Item	Per 5 students	Per classroom*
20-ounce water bottle	1	5
Rubbing alcohol	½ cup	2.5 cups
Tap water	½ cup	2.5 cups
Food coloring	3 drops	1 small bottle
Clear plastic straw	1	5
Modeling clay	About the size of a squash ball	Block of clay

*For a 25 student classroom

Materials: Part 2

Item	Per classroom
Wide mouth juice bottle (i.e. Gatorade bottle)	1
Hardboiled egg	1
Match box	1
Small birthday candles	2
Plate	1

Procedure:

<u>Part 1: Measuring Temperature</u>

Time for this section: 25 minutes

Key Concept: Students will learn how temperature is measured with a thermometer.

Procedure:

1. Introduce temperature. Discuss the various ways temperature is measured (Celsius, Fahrenheit, Kelvin) and ask the students what instrument is used to make those

measurements. After they answer, tell them that they will be building their own thermometer, except without mercury, which happens to be poisonous.
2. Pour rubbing alcohol and tap water into the 20oz water bottle in equal proportions, filling about ¼ of the bottle.
3. Add three drops of food coloring and mix. If there are multiple colors, tell the students to choose whichever one they want.
4. Put the straw into the bottle; make sure that it is immersed in the liquid but not touching the bottom. Emphatically tell the students that they should not drink the mixture or even touch their lips to the straw.
5. Seal the neck of the bottle with modeling clay and hold the straw in place.
6. Ask the students to tell you what they observe. Ask them to take a pen/pencil to mark on the bottle the level of the solution within the straw.
7. Have the students hold the bottle in their hands. This should warm the mixture and the level of the solution should rise. Ask the students why this happens. What is making the level rise?
8. Explain what happens at the molecular level when the temperature rises and falls. In this case, the liquid expands. You can quickly review the states of matter as well. Show how it relates to pressure (the faster that the particles move, the greater pressure exerted; they are directly proportional).

<u>Part 2: Egg in a Bottle Trick</u>
Time for this section: 15 minutes
Key Concept: Combining Pressure and Temperature

Procedure:
1. Tell the students that you need their full attention for the next experiment. Since the experiment involves lighting a match, it is vital that you have everyone's cooperation.
2. Show the students a bottle and a peeled hardboiled egg. Pass it around the class and ask the students if they think that it is possible to get the egg into the bottle without cutting it. Hint that it has something to do with temperature and pressure.
3. Hold the egg in front of the class and over a plate; slowly push two birthday candles into one narrow end of the egg.
4. Light the candles.
5. Turn the bottle upside-down and position it so that it is directly above the lit candles.
6. Slowly bring the bottle down onto the egg and the candles. After several seconds, the candles will go out and the egg should be squeezed into the bottle with minor damage (it depends on the size of the bottle's mouth).
7. Why does this happen? What do you think the flames do to the air within the bottle? Explain that heating the molecules of air causes them to quickly move far away from each other. However, when the flames are extinguished, the particles quickly cool and move together, forming a partial vacuum. Normally, the air outside of the bottle would rush in to fill the vacuum. Since the egg is in the way, the pressure from the outside pushes the egg into the bottle instead.
8. Try removing the egg from the bottle by forcefully blowing into the bottle's opening. The egg should pop out into your mouth.

Clean-up:
Time for section: 5 minutes
Throw Out: water bottles (recycle), straws, used clay, eggs, used candles, plate
Bring Back: extra rubbing alcohol, food coloring, unused clay, unused candles, and matchbox

Background:

Technically speaking, temperature is a measure of the average kinetic energy of particles in a substance. However, temperature is thermodynamically measured by Kelvin, which is an absolute scale (beginning at 0). The Celsius scale is based on the triple point of water (0°C) and absolute zero is -273.15°C. Therefore, to convert Celsius to Kelvin, you simply add 273.15. Though most countries in the world use Celsius, the United States uses Fahrenheit. To convert from Fahrenheit to Celsius use the following equation: °C = (°F-32) * (5/9).

It is also helpful to know the ideal gas law, $PV = nRT$. This formula demonstrates that as the temperature rises, so does the pressure, and vice versa.

Sources:

http://www.stevespanglerscience.com/experiment/00000022
http://en.wikipedia.org/wiki/Temperature

Week 3: Cloud in a Bottle

Objectives: Students will learn what causes clouds to form and how clouds are classified.

Safety Considerations: Don't let the students over-pressurize the soda bottles, or they might explode. Also, they should not eat the cotton balls, drink the isopropyl alcohol, or inhale the air freshener.

CT Science Standards:

Standard	Definition	Implementation
3.1	Materials have properties that can be identified and described through the use of simple tests.	Students will learn to classify and identify clouds.
B INQ. 1	Make observations and ask questions about objects, organisms and the environment.	Students will observe and predict the effects of pressure on systems with different properties (bottles with and without cloud ingredients)

Materials:

Item	Per student	Per classroom*
Cotton ball	1-2	25-50
"Cloud Finder" sheet	1	25
Empty 2L soda bottle (Coke bottles are clear)	1 per group of 4-5	5-6
Fizz Keeper	1 per 2L bottle	5-6
Isopropyl Alcohol (70% or greater)		~250 mL
Glade Powder Fresh Spray (air freshener)		1

*For a 25 student classroom

Procedure:
<u>Part 1: What are clouds?</u>
Time for this section: 5 minutes
Key Concept: Clouds are accumulations of condensed or crystallized water

Procedure:
1. Introduce clouds. You could ask if anyone has looked up at the clouds today (this works well if it's raining or cloudy, predictably), or if anyone has seen clouds from an airplane, etc.

2. Ask if anyone knows what clouds are made of. Explain that clouds are formed from water in the air. If the students are unfamiliar with states of matter, quickly review them. Water in the air is in its gaseous form, called "water vapor". When the temperature of the water vapor decreases, the water that is floating around as a gas "condenses" into liquid on whatever surfaces are available. As an example, ask if anyone has seen their breath look like clouds in the winter – this occurs because warm water vapor inside the body is meeting cold air outside.

Part 2: Classification of Clouds
Time for this section: 20 minutes

Key Concept: There are three main classes of clouds and many subclasses, defined by their height and shape.

Procedure:
1. Ask the students if all clouds are the same. If they are not, then how can we know what to call them? Introduce the concept of classification.

2. Explain that clouds are classified by the height at which they form (the height of the bottom of the cloud), because different 'properties' at those heights make the water in the atmosphere behave differently. Specifically, at higher heights there is less air and therefore less water vapor, and the air also gets much colder, even colder than the coldest winters in New Haven.

3. Help the students imagine the magnitudes of height you are about to talk about – perhaps use the average height of a 4th grader (four feet) or the average height of a school classroom/building story (ten to fifteen feet) and ask them to envision standing on each other's shoulders or stacking multiples of their school on top of each other.

4. You may want to try drawing on the board to illustrate the shapes of these cloud types – don't pass out the Cloud Finder wheel yet because the students will be attempting to make the clouds with cotton balls shortly, and it is difficult to emulate the drawings on the wheel.

5. Introduce the cloud types (see Background for image):

> Stratus – flat, plane-like clouds that usually incite the label of "cloudy day". These clouds form below 6000 ft (600 classrooms or 1500 students), where there is a lot of water vapor in the air. They are mostly made of liquid water droplets.
>
> Cumulus – puffy, round, white clouds that look sort of like cotton balls. They usually form below 8000 ft (800 classrooms or 2000 students).
>
> Stratocumulus – 'large, dark, rounded masses' (Wikipedia) that are also associated with gray or 'dull' weather. Sort of look like a bunch of cumulus clouds pressed together. Also form below 8000 ft.
>
> Altocumulus – these look almost the same as stratocumulus, but they tend to occur in smaller patches and vary widely in height, from 8000 up to 20000 ft (2000 classrooms or 5000 students) – higher altocumulus are more likely to cause rain.
>
> Cumulonimbus – these are the tallest clouds and come from cumulus clouds; however, they are extended upward by wind currents. These cause thunderstorms and are the most frightening clouds; the base can begin at a few thousand feet and

extend up to tens of thousands of feet.

Cirrus – the more innocent cirrus clouds are formed very high up, above 25000 ft. (2500 classrooms or 6250 students); they are made completely of tiny ice crystals (solid water, which is frozen because it's so high up). Because there isn't as

If you think they can handle it, group the stratus, cumulus, and stratocumulus into the "low" cloud group, altocumulus into the "middle" cloud group, cumulonimbus into the "vertical" cloud group, and cirrus into the "high" cloud group (based on their heights).

5. Pass around the cotton balls, and ask the students to pick one of the cloud types that you've just told them about and try to make it from the cotton balls. Give them a couple of minutes, then go around and have them show the class what they made.

<u>Part 3: Cloud in bottle</u>
Time for this section: 20 minutes
Key Concepts: Recap of "what are clouds?" concepts.

Procedure:

1. Build anticipation by informing the class that you are now going to make clouds. Split the class into groups of four or five and give each group a 2L soda bottle and a Fizz Keeper. Have them feel the bottle, noting that it is easily squeezed.

2. Have them screw on the Fizz Keepers and start pumping them, letting them take turns for a total of about 80 pumps. Ask them if they notice anything different about the bottles or what is inside them – the bottles should be very stiff but still clear. Do they expect something to happen when you take off the Fizz Keeper?

3. Let them remove the Fizz Keepers – nothing should happen except that the bottles will become easy to squeeze again. Keep them from being disappointed by asking what they think might be missing. What are the ingredients of a cloud?

4. We need water – what for? The water vapor needs to condense on pieces of stuff to make clouds. Since we just need some kind of vapor, we'll use isopropyl alcohol as a substitute. Basically, this will give us more water-like stuff in the air to condense on the pieces of stuff because alcohol vaporizes more easily. Add enough isopropyl alcohol to each bottle to cover the raised central portion of the bottom and rotate it in the bottle to wet the sides (to promote vaporization). Is anything else needed?

5. We need pieces of stuff for the water to condense on. Spray some air freshener into the each bottle. (Holding the bottle at an angle, point the hole of the can of Glade directly at the opening of the bottle and give one spray of the freshener into the bottle. You may get quite a bit of freshener on the side of the bottle, but as long as you see a good cloud of freshener get sprayed into the bottle, there should be enough particles floating around as well for the alcohol to condense on. Swirl the isopropyl alcohol to dissolve any air

freshener that does get on the sides of the bottle so the cloud is easier to see.)

6. Repeat the first two steps. This time, a cloud should appear when you loosen the Fizz Keeper (though not before; it should look like there is fog inside the bottle). The cloud should stay for awhile, though if you like you can have them replace the Fizz Keepers and pump them to make the cloud disappear again. If they repressurize the bottle enough, removing the Fizz Keeper will make the cloud reappear too.

7. Explain it – when we swirled the bottle around, bits (molecules) of alcohol (simulating water) left the alcohol we put into the bottle and went into the air inside the bottle, becoming gas. The air freshener provided surfaces for the alcohol vapor to stick to and condense on, and when we opened the Fizz Keeper, the temperature in the bottle suddenly decreased, and as we know, sudden decreases in temperature when there is a lot of vapor and things for it to condense on is the recipe for clouds.

8. Lastly, pass out the Cloud Finder wheels and tell the students they can now go cloud-hunting and identify all the clouds on their way home.

<u>Clean-up:</u>
Time for section: 2 minutes
Throw Away: Cotton balls, Isopropyl alcohol in bottles (pour down drain along with running water. Allow water to run for 2 min.)
Recycle: 2L bottles
Bring Back: Fizz Keepers, Unused air freshener, Unused isopropyl alcohol

Enrichment:
A couple of topics could be covered if there is extra time. The basis of the temperature rise and fall with the pressure (PV=nRT) could be explained (though probably not in too much detail). Also, the reason for precipitation, too much water vapor resulting in condensation into droplets or crystals large enough to fall down to earth, could be given.

Background:
For shapes of clouds, besides Cloud Finder, see below (ignore cirrocumulus)

Chemistry Unit

Chemistry can be a good and bad thing. Chemistry is good when you make love with it. Chemistry is bad when you make crack with it.

-Adam Sandler

Week 4: Magic Solutions

Objectives: Students will observe the process of dissolving a solute in a solvent and a few basic properties a solution can have.

Safety Considerations:
The packing peanut demonstration involves acetone, which should be kept in the jar and out of reach of the students.

CT Science Standards:

Standard	Definition	Implementation
3.1	**Materials have properties that can be identified and described through the use of simple tests.**	Students will see that different amounts of solute give the solutions different densities.
3.3	**Earth materials have different physical and chemical properties.**	Students will see packing peanuts dissolve in acetone but not water.

Materials:

Item	Per student	Per classroom*
50 mLnail polish remover (contains acetone)		1
Covered Jar with nail polish remover		1
Bag of Packing Peanuts		1
Small clear cups	1	25
Cups for each solution	3 per table	20
Food coloring	n/a	1 Pack
Spoons	1	25
Salt	9 T per table	45 T
Popsicle sticks	3 per table	15

*For a 25 student classroom, with 5 tables of 5 students

Procedure:
<u>Part 1: Magical Introduction of Dissolving Packing Peanuts</u>
*Time for this section:*15 minutes
Key Concept: Certain solutes dissolve only in specific solvents

Procedure:
1. Place the covered jar of nail polish remover on the table and ask the kids how many packing peanuts they think can fit in the jar
2. After writing down a few good guesses, start slowly adding the packing peanuts
3. Once you have surpassed the highest guess, start adding the rest of your supply, but leave a couple for later

4. When the kids are substantially amazed, remove the jar's covering to reveal the nail polish remove solution, which has been dissolving the packing peanuts
5. Explain that you have just made a solution, what a solution is, and which components acted as the solute and solvent (Hint: the nail polish remover is the solvent, and the peanuts are the solute)
6. Tell them that solutes are "picky" in that they don't dissolve in everything
7. Fill one of your cups with water, ask the students how many packing peanuts will dissolve and show that the packing peanuts do not dissolve in water

<u>Part 2: Solution Rainbow</u>
Time for this section: 30 minutes
Key Concept: Different amounts of dissolved solute give the solutions different densities

Procedure:
1. Tell them that water can dissolve other things, and ask them to name a few things that dissolve in water – Ex: salt, sugar, Kool-Aid drink mixes, and hot chocolate powder
2. Give each student a clear plastic cup and a spoon
3. Give each table three cups with ¾ cup water in each. Add a couple drops of red, yellow, and blue dye to the respective cups
4. Add no salt to the red one, 2 tablespoons of salt to the yellow, and 4 tablespoons of salt to the blue one
5. Have the students pour a small amount of the blue solution into their cups
6. Have each student pour the yellow solution slowly over the back of the spoon into the cup, emphasize the slow speed to make sure the colors don't mix
7. Do the same for the red solution, creating a stack of colors in each cup
8. Explain the concept of density, and that lighter densities float on top of greater densities, use ice floating in water as an example

<u>Clean-up:</u>
Time for section: 10minutes
Throw Out: All cups and spoons
Bring Back: Covered jar with nail polish remover, leftover salt, food dye, and packing peanuts

Enrichment:
If the students want to know why the packing peanuts dissolved in nail polish remover but not water, you can explain that "like dissolves like", and that both the nail polish remover which contains acetone and packing peanuts are nonpolar, while water is polar.

Background:
Styrofoam is made up of long strands of styrene molecules with lots of air pockets. These nonpolar molecules are soluble in the nonpolar solvent, acetone. This demonstration also shows students that Styrofoam is not an easily recyclable product as it is hard to break down with ordinary substances, such as water.

Density is a material's mass per unit volume. In this experiment adding more salt (more mass) to the same volumes of water created different densities. Less dense solutions will float on top of more dense solutions. This is why ice floats in water and glaciers exist in the north and south poles.

Sources:
http://www.stevespanglerscience.com/experiment/00000046
http://en.wikipedia.org/wiki/Density

Background:
There are three primary states of matter (solid, liquid, gas). Additionally scientists have observed three other states in more extreme conditions (plasma, Bose-Einstein condensate, fermionic condensate). Each of the states has properties that distinguish it.

Solid: definite shape and volume
Liquid: indefinite shape, definite volume
Gas: indefinite shape and volume

Matter inter-converts between these various forms depending on pressure and temperature. For example, heating a liquid forms a gas while increasing the pressure on a liquid forms a solid.

In the making of ice cream, a liquid mixture is turned into a solid by lowering the temperature. A key element is the salt. Just as when icy roads are salted, the freezing point of the ice is lowered and the ice melts more quickly. Melting is an endothermic process, that is it requires heat from the environment. In this case, heat is sucked away from the ice cream mixture, causing its temperature to fall.

Sources:
States of matter: http://en.wikipedia.org/wiki/States_of_matter

Week 5: Invisible Ink

Objectives: Students will learn about chemical reactions and create two kinds of invisible ink using cornstarch, lemon juice, and iodine.

Safety Considerations: Students should not eat any of the materials or touch their eyes. Clean up spills immediately and wash hands after using iodine.

CT Science Standards:

Standard	Definition	Implementation
3.1	Materials have properties that can be identified and described through the use of simple tests.	Students observe color-changing reactions between common household substances.
A INQ.4	Make predictions based on observed patterns.	Students use observed reactions to reveal “invisible” messages.

Materials:

Item	Per group (3-4)	Per classroom*
Paper bathroom cups	2	16
Cornstarch	1 spoonful	1 bag
Lemon juice	¼ cup	1 bottle
White paper	4 (1 sheet per student)	25
Q-tips	4	25
Toothpicks	4	25
Cotton balls	4	4
Plastic spoons		2
Clear plastic cups		4
Dilute iodine solution**		1 bottle
Water	¼ cup	

*For a 25 student classroom
**Materials prep crew: to make the iodine solution mix 1 part 10% povidone-iodine solution (found at most drugstores) with 10 parts water.

Procedure:

<u>Part 1: Introduction to Chemical Reactions</u>
*Time for this section:*5 minutes
Key Concept: Materials can react with each other to form new substances.

Procedure:

1. Ask students to describe and define a chemical reaction. Can you mix any two things together to create a reaction? How can you tell if two substances have reacted? What are some examples of chemical reactions?
2. Explain that a chemical reaction takes two starting materials (reactants) to make one or more different materials (products). Older students might know that everything is made of tiny particles called atoms. In a chemical reaction, these particles are rearranged, resulting in the formation of a product. You cannot separate the starting materials from the final compound because they have been changed at the atomic level.
3. One way to see that a chemical reaction has occurred is if the product is a different color from the reactants. Today, we will use color-changing reactions to make invisible ink.

<u>Part 2: Making the Ink</u>

Time for this section: 15 minutes

Key Concept: Chemical reactions from common materials can have neat applications!

Procedure:

1. Give each student a sheet of paper. Students may choose to fold their paper in half and use one side for each type of ink.

2. To make cornstarch ink, give each group a small cup quarter-filled with water. Add a spoonful of cornstarch and let students stir the solution with toothpicks. The solution should be cream colored with some solid cornstarch at the bottom of the cup. (It won't work as well if it's too diluted.)

Let students write with the cornstarch using toothpicks. Remind them to re-dip the toothpick often so that each letter has plenty of starch in it.

3. To make lemon juice ink, give each group a small cup of lemon juice and have them write with it using Q-tips.

4. Set the paper aside to dry completely— the writing will disappear in a few minutes.

<u>Part 3: The Reactions Involved</u>

Time for this section: 5 minutes

Key Concept: Cornstarch and lemon juice each react with iodine.

Procedure:

1. While the messages are drying, demonstrate the reactions involved in today's experiment. Pour cornstarch solution, lemon juice, and iodine into three clear plastic cups. Let students observe the color of each solution.

2. Have students predict what will happen when cornstarch is mixed with iodine. Then, test their predictions by pouring some of the iodine into the cornstarch. The white starch solution will turn purple/blue. What happens when you add more iodine to the solution?

3. Have students predict what will happen when lemon juice is mixed with iodine, then test their hypotheses. The lemon juice will remain yellow even when brown iodine is added.

4. Now that they've seen the reactions, ask students to predict what color their messages will turn when iodine is added to the paper.

Part 4: Revealing the Messages
Time for this section: 10 minutes
Key Concept: Iodine can be used to uncover the invisible messages from Part 2.

Procedure:
1. Demos volunteers should each go around the classroom with a cup of iodine. Give each student a small amount of iodine on a cotton ball.
2. Have students blot their paper to reveal the invisible messages. The cornstarch will reveal dark purple letters on a pale blue/purple background. The lemon juice will reveal white letters on a pale blue/purple background. (The paper changes color because it contains some starch.)
IMPORTANT: Too much iodine will turn the entire paper dark blue and make it difficult to see the ink. Use just enough iodine to moisten the paper. Help younger students with this step if needed.

Clean-up:
Time for section: 5 minutes
Throw Out: used cups, cotton balls, toothpicks, etc, used liquids
Bring Back: any unused materials

Enrichment:
If there is extra time, have students discuss the similarities and differences between their two types of invisible ink. Which had better results? Are there any areas for improvement?
There are many other ways to make invisible at home. Here are a few examples:
- Baking soda and grape juice
- Lemon or apple juice and heat
- Phenolphthalein (common in laxatives) and ammonia

Background:
A chemical reaction occurs when two or more reactants come together to form products that are chemically unique from the starting materials. A chemical compound is different from a mixture because it cannot be separated into its constituent substances. Characteristics of chemical reactions include bubbling (gas formation), temperature changes and color changes.

Invisible ink is a fun application of color-changing chemical reactions. One reactant, the ink, dries colorless. The other reactant causes a color change to reveal the hidden message. Acid-base and redox reactions are a few methods to create invisible ink.

Iodine is a common indicator for starch. Amylose, a spiral-shaped molecule, is the component of starch responsible for the dark blue/purple color that forms when iodine is added. Natural starch is 10-20% amylose. In an iodine solution, iodine (I_2) and iodide (I^-) combine to form triiodide (I_3^-). The triiodide ion slips inside the amylose coil, and the resulting complex gives the solution its dark color.

Lemon juice works as an invisible ink because it contains ascorbic acid (aka vitamin C), which interferes with the iodine-starch reaction. As a result, messages written in lemon juice will remain white when treated with iodine. Ascorbic acid is also easily oxidized. Instead of using iodine, messages written in lemon juice can be heated with a light bulb or iron to reveal the writing (in brown).

Sources:

http://www.fact-index.com/i/in/invisible_ink.html
http://www.elmhurst.edu/~chm/vchembook/548starchiodine.html
http://aob.oxfordjournals.org/cgi/content/abstract/65/3/281

Week 6: Silly Putty

Objective: Identify properties of liquids and solids, and introduce the concept of *slime*, which has properties of both. Discover that everyday objects (i.e. toothpaste) can have such properties, and learn the reasoning behind this (i.e. "a chemical reaction").

CT Science Standards Met:

Standard	**Definition**	**Why**
A INQ.1/B INQ.1	Make observations and ask questions about the environment.	Students observe what happens in the reaction between borax and water/glue.
Grade 2 A.1	Describe differences in the physical properties between solids and liquids.	Students brainstorm properties of solids and liquids then observe the slime, recognizing that slime contains properties of both.

Materials:

Unit	Quantity per classroom
Borax—20 tablespoons (or as many as needed such that water: borax is in a 1 cup to 1 tablespoon ratio. You'll have at least 20 tablespoons in your Demos bag.)	20 Tablespoons
Water— ¼ cup per student	Get from sink at school (this is for the students' mixtures)
Glue— ¼ cup per student (clear glue is most desirable because it looks like slime)	8 cups
Food coloring	Food coloring kit
Ziploc bags—1 per student	35 bags
1 Popsicle stick	35 sticks
1 cup	35 cups
1 spoon	35 spoons
Baking Soda	1 bag
Vinegar	1 small bottle

*for a classroom of 35 students

PART 1. Estimated Time: 10-15 minutes

Talking Points

Ask students whether they remember what a "chemical reaction" is—chances are they do from the previous protocol. Explain this in your own words (such as "when different chemicals mix with each other to make something"). Explain the difference between a mixture and a chemical compound (use something like trail mix to exemplify a mixture), and explain that mixtures can be separated into the things that make them up whereas chemical compounds cannot.

Now that you've done this, explain that when chemical reactions happen, the "stuff" that forms may be different from what makes it up.

Show them the borax, glue, food coloring, and water. Ask whether these are solids, liquids, etc. and ask about their properties. Make a list of their responses on the board.

Next, show them a simple example of a chemical reaction. Explain that when certain chemicals react, certain "properties" are triggered (find a better word if possible). Explain, if need be, that "properties" are basically "what the chemical does".

NOTE: You can skip this next step if you're short on time

While the baking soda-and-vinegar reaction is common, many of the kids probably haven't seen it. You'll have some baking soda and vinegar in your bag. Show them this reaction—take care to not make a mess! If your classroom has a sink, it's a good idea to do it over the sink.

Tell the kids that today they'll be making silly putty, a type of 'slime'. (They should hopefully know what these are). Tell them that slime has properties of both liquids and solids, and ask them if they know of other things like that. If you can, prompt them to come up with the substances themselves. Common examples are toothpaste, ketchup, etc.

Write some properties of liquids and solids on the board (again, take student response first, and append to the list as necessary). Later on, as students are playing with the slime, go around the classroom asking them to identify which of the solids' properties the slime has and which of the liquids' properties the slime has. **As a short-on-time alternative, you can prepare a list at home and give a copy to each student.**

Remember the students' grade level when considering what to write down and/or explain—keep things simple!

PART 2. Estimated Time: 20 minutes

1. Add ¼ cup of glue to each student's cup.

2. Add food coloring as the kids want (but no more than 2 drops—you should probably add it yourself after asking for their choice), and give them the option to mix colors as desired.

3. Add ¼ cup of water and ¼ tsp of borax to each kid's cup and tell them to keep stirring (it can take a little while). When slime begins to form have the students pull it out of the cup and begin rolling it around between their hands. Explain that as they play with it, it will become less sticky. (*Make sure they don't pull the slime out too soon!)*

4. As the students are playing with their slime, go around the classroom talking to them about the properties of the slime. Ask them which properties of liquids the slime has, and which properties of solids the slime has (reference the list on the board as need be).

5. Have them put the slime in their bags and seal the bags tightly. They're allowed to bring the silly putty home.

PART 3: Clean Up Estimated time: 5 minutes

Bring Back**:** Glue, food coloring, any unused items (popsicle sticks, spoons, Ziploc bags, etc), water tub

Throw out at the school**:** Everything else

Background:

When baking soda and vinegar come together, they react to produce three products: sodium acetate, water, and carbon dioxide gas, the most visible. Advanced students may be told this is an example of an acid (vinegar)-base (baking soda) reaction. On the other hand, when Mentos comes together with Diet Coke, the candy provides places for the already present gas to come out of solution and be released. Hence, no chemical reaction is present.

The borax is acting as the crosslinking agent or "connector" for the glue (polyvinyl acetate) molecules. Once the glue molecules join together to form even larger molecules called polymers, which include all types of plastic. The slime is actually what is known as a "non-Newtonian" fluid. In the 1700s, Sir Isaac Newton described the properties of ideal fluids. He said an ideal fluid would have a constant viscosity, or resistance to flow, at a given temperature. The slimes has the properties of both a liquid and a solid. It also reacts to stress with increased viscosity. The name for the study of the change in form and flow of materials is rheology. Water and most liquids are Newtonian fluids because their viscosities do not change when a stress is placed on it.

Non-Newtonian fluids can be both found in nature and created artificially. The viscosity of these fluids does change when they are put under stress. Natural examples are tree sap, saliva, and even DNA. Artificial examples are tomato ketchup, glue, and toothpaste.

Sources:

http://www.riverdeep.net/current/2001/12/120301_simplescience.jhtml
http://www.madsci.org/experiments/archive/878680114.Ch.html

Week 7: The Power of Iron

Objectives: To understand the nutritional, biological, and magnetic importance of iron

Safety Considerations: Advise the student to NOT eat the iron filings from Part 1 of the experiment (even though they are allowed to eat the iron from the cereal in Part 2).

CT Science Standards:

Standard	Definition	Implementation
4.4.B16	Describe the properties of magnets, and how they can be used to identify and separate mixtures of solid materials.	Students observe the properties of magnetism and magnetic field lines using magnets and iron filings.
2.4	Human beings, like all other living things, have special nutritional needs for survival.	Students extract iron particles from cereal and understand their biological and nutritional importance.

Materials:

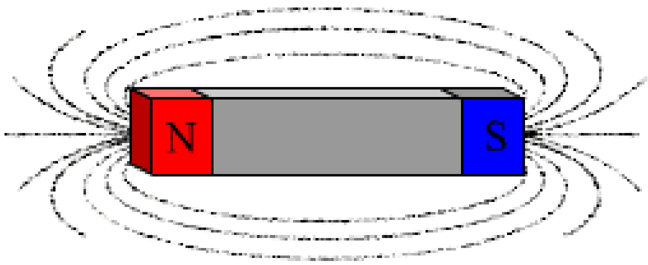
Item	Per group (5 students)	Per classroom*
Iron filings	Vial	5 Vials
Cereal (fortified with iron) Recommended: Kellog's Product 19 or General Mills' Total	Half a bowl	1 Box
Paper bowls	1	5
Spoons	5	25
Magnets	5	25
Napkins	5	25

*For a 25 student classroom

Procedure:

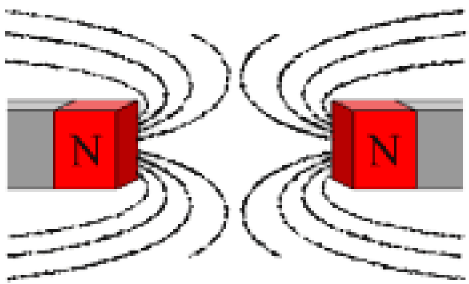
<u>Part 1: Discovering Magnetic Field Lines with Iron Filings</u>
Time for this section: 20 minutes
Key Concept: Magnetism and Magnetic Fields

Procedure:
1. Discuss and define magnetism (attraction or repulsion of materials because of magnetic forces). See **Background** to understand what makes a material magnetic.
2. Pass out a magnet to each student and have him or her test the magnetic forces by putting two magnets closer together (since each student will have one magnet, students should work in pairs).
3. Now split the class into groups of 5 and have each group place one magnet on a napkin.
4. Sprinkle iron filings over and around the magnet.
5. Observe and analyze the pattern that forms (the iron filings should make a pattern that resembles the magnetic field lines).



[1]

6. Discuss the significance of these iron filing patterns (magnetic field lines) and explain that iron can be used to physically visualize the invisible magnetic field. Cool!
7. Now place two magnets together and observe how the filings change shape. (Note that depending on whether the two magnets are placed S-N-N-S or N-S-N-S, the patterns should be different).



[1]

<u>Part 2: (Iron Extraction)</u>
Time for this section: (25) minutes
Key Concept: Nutritional and Magnetic Properties of Iron

Procedure:
1. Ask the class if anyone eats cereal for breakfast. Discuss the nutritional importance of cereal (high energy, protein, fiber, fatty acids, vitamins, and iron etc.)
2. Discuss the nutritional and dietary importance of iron (delivery of oxygen via RBCs, proper functioning of immune system, and improved production of energy).
3. To each group of 5 students, pass out a paper bowl.
4. Pour cereal into each bowl until it is a quarter full.
5. Add water to the bowl of cereal until the cereal is covered.
6. Crush the cereal with a spoon until it is broken down into fine pieces.
7. Stir a magnet inside the bowl.
8. Wipe the magnet (with the iron filings) onto a paper napkin in order to collect the iron. particles from the cereal.
9. Compare the iron filings from the previous experiment with the iron particles that were extracted from the cereal. Discuss the physical differences between the two. (The iron filings used in the previous experiment should be much larger and more course. The iron extracted from the cereal should be much smaller and finer.)
10. Allow the students to eat any remaining cereal if they want to!

Clean-up:
Time for section: 5 minutes
Throw Out: Used and crushed cereal, used spoons, used paper bowls, and used napkins
Bring Back: Magnets, iron filings, and all unused goods (cereal, napkins, paper bowls, spoons, etc.)

Enrichment:(Activities if there is extra time or for older students)

Background:
What makes a material magnetic?[3]
"In magnetic materials, sources of magnetization are the electrons' orbital angular motion around the nucleus, and the electrons' intrinsic magnetic moment. The other potential sources of magnetism are the nuclear magnetic moments of the nuclei in the material which are typically thousands of times smaller than the electrons' magnetic moments, so they are negligible in the context of the magnetization of materials...The magnetic behavior of a material depends on its structure (particularly its electron configuration, for the reasons mentioned above), and also on the temperature (at high temperatures, random thermal motion makes it more difficult for the electrons to maintain alignment)."

Biological and Dietary Importance of Iron[2]
"Iron is found in every cell of your body and is an essential component of hemoglobin, the protein in red blood cells that carries oxygen to tissues throughout the body. Iron is also found in myoglobin, which distributes oxygen to the muscle, skeletal, and heart muscles. Iron is also critical to the proper functioning of the immune system and the production of energy. Insufficient iron stores in the body can lead to anemia and other illnesses. Women who are menstruating, pregnant, or lactating are at an increased risk for iron deficiency."

Sources:

[1]http://www.ndt-ed.org/EducationResources/HighSchool/Magnetism/magneticfields.htm
[2]http://www.parentingweekly.com/pregnancy/breathingspace/vol18/pregnancy_health_fitness.asp
[3]http://en.wikipedia.org/wiki/Magnetism
[4]http://www.boloji.com/health/articles/01058.htm

Biology Unit

"**Biology** has at least 50 more interesting years."

-James D. Watson

Week 8: Extremophiles

Objectives: Students will learn about extremophiles, how they are classified, and how organisms evolve to exist in specialized environments.

Safety Considerations: Do not let students eat any of the items used in the protocol.

CT Science Standards:

Standard	Definition	Implementation
3.2	Organisms can survive and reproduce only in environments that meet their basic needs.	Students will learn about extremophiles and how they are adapted to survive in their unusual environments.
B.INQ.3	Design and conduct simple investigations.	Students will carry out an experiment to determine optimal growing conditions for yeast.

Materials:

Item	Per student	Per classroom*
Terminology Sheet	1	25
500 mL soda bottle	1 per group of 4-5	4
Balloons	1 per group of 4-5	4
Beaker (≥200 mL)	1 per group of 4-5	4
Funnel	1 per group of 4-5	4 (or 1/classroom)
Teaspoon		1
Yeast (1 packet ~ 2 tspn)	1 pkt per group of 4-5	4
Sugar	4 tspn per group of 4-5	20 tspn
Salt		1/3 cup
Vinegar		4 mL (1 tspn)
Sharpie		1

*For a 25 student classroom

Procedure:

<u>Part 1: Introduction</u>

Time for this section: 5 minutes
Key Concept: Extremophiles are organisms that have evolved to thrive in environments that seem extreme to humans.

Procedure:

1. Ask the students what sort of environments they like to live in the best. Do they enjoy the cold winter, or maybe lots of sunlight and heat? Or maybe they like something in between. Introduce the idea of habitats.
2. Mention the concepts of evolution and adaptation – organisms can adapt to different habitats by developing biological changes over long periods of time. This is similar to the development of different types of beaks, blubber, and skin camouflage
3. Ask students if they know what bacteria are? Mention that some bacteria have adapted to survive in extreme environments that would be inhospitable to most organisms we see around us. For example, some bacteria live in volcanic vents or deep in the ocean, where humans would die from burns or pressure. These organisms are called *extremophiles*, meaning "extreme [environment]-loving".

<u>Part 2: Yeast Growing Experiment</u>

Time for this section: 15 minutes (part 1), 10 minutes (part 2)
Key Concepts: Organisms can grow in many environments, but environments outside their adaptation result in sub-optimal growth.

Procedure:
1. Briefly review the scientific method (question, observation, hypothesis, experiment, analysis and conclusion).
2. Tell the students that they will apply the scientific method to study how yeast grows in various environments. Give a little bit of background on yeast – how it is commonly used in baking bread.
3. Introduce the environments: warm water, warm vinegar water, warm salt water, and cold water. Explain that the students will be trying to grow yeast in these four environments, and that they will see in which environment the yeast grows best.
4. Divide the students into four groups, providing each group with a soda bottle, and help them put 2 teaspoons of yeast and 4 teaspoons of sugar in each bottle (using the funnel if necessary). Then give each group a beaker and have them mix the following solutions:
   -200 mL warm water
   -200 mL warm water plus 4 mL vinegar
   -200 mL warm water plus 1/3 cup salt
   -200 mL cold water
   (taking all water from the tap)
Make sure they add their solutions via the funnel before it cools. Seal the bottles with balloons by stretching the opening over the tops as quickly as possible after pouring in the solutions. Label each bottle with the sample it contains, and collect the bottles on an unused desk during the next activity.

<u>Part 3: Terminology of Extremophiles</u>

Time for this section: ~20 minutes
Key Concept: Extremophiles are classified by the environments in which they live, and special words are used to classify them.

Procedure:

(This section is partly meant to occupy roughly 20 minutes so that the yeast can grow and produce carbon dioxide, inflating the balloons based on how well they grow – the warm water yeast should grow well and the other samples should grow less well)

1. Explain that there are many types of extremophiles, and that scientists need to keep track of them all. In order to do so, e need to classify extremophiles so we know what environments they are known to live in. If necessary, clarify the concept of classification.

2. Pass out a terminology sheet to each student and explain that scientists use special words to express the environments in which extremophiles live. The first part of the word, the *prefix*, indicates the type of environment, and the second part of the word, the *suffix* (*-phile*) for each case here, means that the organisms 'love' that type of environment. The terms are:

acidophile (*acid* = acid)	likes acid
halophile (*halo* = salt)	likes salt
thermophile (*thermo* = heat)	likes heat
cryophile (*cryo* = icy cold)	likes cold
xerophile (*xeros* = dry)	likes dryness
osmophile (*osme* = smell)	likes sugar

   You may write the terms on the board so the students know how they are spelled.

3. Have the students circle the terms on the sheet and connect them to the appropriate images using lines.

4. Note that our experiment will test whether yeast is one or more of these types of organism. Ask the students if they can identify which types of extremophiles they are testing for. If necessary, hint that vinegar is an acid.
   Students can keep the terms sheets.

5. If you need to fill more time, you can discuss the application of extremophiles to astrobiology. After extremophiles were discovered, scientists began to wonder if organisms could develop to live in any environment, including the 'harsh' environments found in space, with little oxygen and water and extreme cold and heat, for example. (Perhaps mention that 'harsh' can be a matter of perspective, because extremophiles' native environments are perfectly hospitable to them.) Talk about the idea of sending extremophiles to far away hot planets like Venus or even farther away cold planets like Mars.

6. Direct the students' attention to the yeast-containing soda bottles. The warm water yeast should have inflated the balloon more than the cold water or water with vinegar or salt.

7. Ask the students to come up with conclusions based on these observations. They may note that yeast grows well in warm water without vinegar or salt, meaning that these organisms are not acidophiles or halophiles.

7. Point out that though yeast grows well in warm temperatures, it is not considered a thermophile because thermophiles tend to live in hotter environments. Instead, yeast could be called a *mesophile,* an organism that lives in moderate conditions.

8. Ask the students if they can classify humans using one of the terms they just learned. Do we love salt, or dryness, or lots and lots of sugar? Generally, humans are best described as mesophiles.

Clean-up: *Time for section:* 4 minutes
Throw Away: Pour out yeast solutions, Soda bottles, balloons
Bring Back: Funnels, Spoon, Beakers, Sharpie

Enrichment:

If there is interest or intellect, you could discuss the scientific basis for extremophiles' durability – variations in the proteins and protein content of their cells, for example, allow these organisms to survive in their environments, including changes that prevent proteins from denaturing or becoming inactive at high temperatures, as equivalent proteins in humans would.

Background:

Simple map of scientific method (from Scientific Method on Wikipedia):

A linearized, pragmatic scheme of the four points above is sometimes offered as a guideline for proceeding:

Define the question
Gather information and resources (observe)
Form hypothesis
Perform experiment and collect data
Analyze data
Interpret data and draw conclusions that serve as a starting point for new hypothesis

The iterative cycle inherent in this step-by-step methodology goes from point 3 to 6 back to 3 again.

Extremophiles and astrobiology (from Wikipedia):

Astrobiology is the field concerned with forming theories, such as panspermia, about the distribution, nature, and future of life in the universe. In it, microbial ecologists, astronomers, planetary scientists, geochemists, philosophers, and explorers cooperate constructively to guide the search for life on other planets. Astrobiologists are particularly interested in studying extremophiles, as many organisms of this type are capable of surviving in environments similar to those known to exist on other planets. For example, Mars may have regions in its deep subsurface permafrost that could harbor endolith communities. The subsurface water ocean of

Jupiter's moon Europa may harbor life, especially at hypothesized hydrothermal vents at the ocean floor.

Sources:

http://www.lessonsnips.com/lesson/extremophile
http://www.theguardians.com/Microbiology/gm_mbm04.htm
http://www.lpi.usra.edu/education/fieldtrips/2007/activities/whats_your_limit.pdf
http://ares.jsc.nasa.gov/Education/Websites/AstrobiologyEducation/Data/justright.pdf
http://www.its-about-time.com/htmls/astro/tgc12a2.pdf

Week 9: Plant Biology

Objectives:
Students will learn about the various parts of a plant and their respective functions. They will also carry out an experiment to test the requirements of seed germination.

Safety Considerations:
None of the materials should be ingested, since there may be allergies.

CT Science Standards:

Standard	Definition	Implementation
2.2	Plants change their forms as part of their life cycles.	Students explore and describe the effects of light and water on seed germination and plant growth.
B INQ.1	Make observations and ask questions about objects, organisms and the environment.	Students dissect and observe the anatomy of a seed; students observe germination and plant growth over two weeks.

Materials:
*For a 25 student classroom

Item	*Per group of 3*	*Per classroom**
Blue food coloring		1 bottle
Celery stalk		1
Plastic knife		1
Heavy plastic cup		1
Seed diagram	1	9
Clear plastic cup	1	9
Sharpie marker		1
Ziploc bag		1
Paper towels	3 sheets	1 roll
Dry lima bean	1	9
Lima bean soaked overnight	2	18

Procedure:
<u>Part 1: Plant parts</u>
Time for this section: 15 minutes
Key Concept: The main components of plants are roots, stems and leaves; Flowering plants additionally have flowers, fruits and seeds. Each plant part has a specific function for the plant.

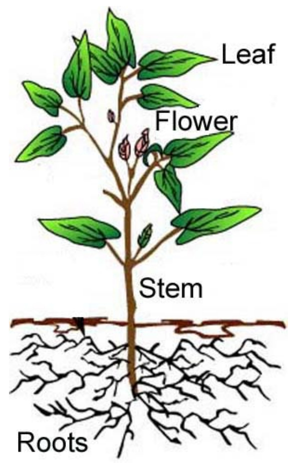
Procedure:
1. ****Prepare this celery stalk demo as soon as you enter the class**** Fill a heavy plastic cup about ¾ the way up with water and add as much blue food coloring as needed to make the water

dark with color; cut about an inch off the bottom of the celery stalk and place in the cup with the leaves sticking out

2. Start off by asking: What is a plant? What makes plants different from animals?

3. Explain that plants are living things just like animals, but unlike animals they can't move quickly (with a few exceptions e.g. Venus fly trap) and they can produce their own food from sunlight.

4. Draw a basic picture of plant on the black/whiteboard and ask students to name the parts and describe the function of each. Fill in any that they miss and give food examples



a. Roots – absorbs water and nutrients from the soil; anchors plants in soil; stores extra food (e.g. carrots, beets, turnips)

b. Leaves – captures sunlight to produce food for the plant (cabbage, lettuce, spinach)

c. Stems – supports the plant; conducts water and nutrients from the roots up to the leaves; conducts food from the leaves down to the roots (celery, asparagus, potatoes)

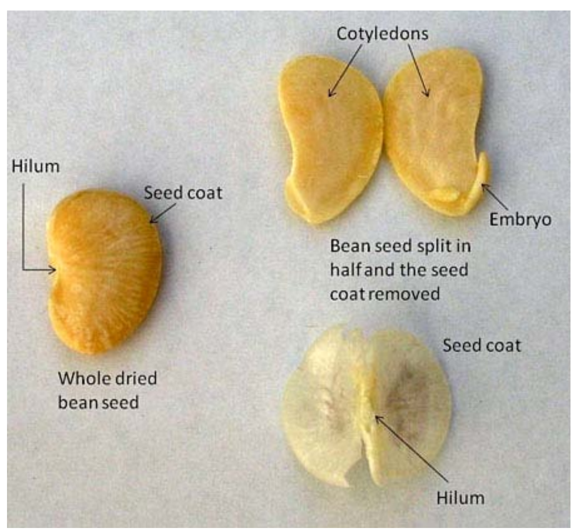
5. Explain that flowering plants have additional structures like flowers, fruits and seeds that help the plants make more plants

<u>Part 2: Seeds & Germination</u>

Time for this section: 30 minutes

Key Concept: Seeds contain a seed coat, a nutrient store and an embryo (a baby plant), complete with parts that will later become a mature plant; lima beans need water, light and air to germinate; imbibed/soaked lima beans germinate faster than dry ones.

Procedure:



1. Hand out a copy of the seed diagram to each group of 3 students

2. Hand out 1 soaked lima bean to each group, and ask them to gently slip off the seed coat. Explain that the seed coat, called the **testa**, protects the seed from damage and from drying out, and that it softens when there is enough water in the surroundings to sustain a growing plant.

3. Instruct them to gently slip a fingernail in the seam on the convex (rounded) side of the bean to split apart the bean (Help out if necessary). Explain that the two large lobes called **cotyledons** (pronounced *cot-i-lee-duns*) store the nutrients necessary for the baby plant to take root and emerge from the soil

4. Instruct them to closely observe the **embryo**; they should see the **radicl**e, the long structure that will later develop into the root, and the **plumule** (the first true leaves) that are nestled between the cotyledons (See figure for reference)

5. Hand out another soaked lima bean, 1 dry lima bean and 3 paper towel sheets to each group. Randomly assign 3 groups to be "Without Air," "Without Light," and "Without Water." All other groups will be "Control" groups.

a. "Control" groups – Give the groups a plastic cup and instruct them to wet their paper towels; fold one moist towel to line the inside of the cup (the moisture should help it stick), and bunch up the remaining towels in the bottom of the cup. Slide the soaked and dry lima beans between the paper towel and the wall of the cup, and label them with a Sharpie on the outside of the cup. Fill up the cup with water about 2 cm deep but make sure the beans are above the water line. Place in a sunlit location and keep towels moistened

b. "Without Light" – Repeat the control group procedure but place the cup in a dark location

c. "Without Water" – Repeat the control group procedure but do not wet the paper towels

d. "Without Air" group – Give the group a Ziploc bag and instruct them to wet their towels; fold the dry and soaked lima beans between the wet towels and seal the bag so that it is airtight; use a Sharpie to label which bean was placed in which side of the bag; place the Ziploc bag in a sunlit location

6. **Remind the students and the teacher to keep the paper towels moistened for another week (except the "Without Water" group)** Tell the students to keep an eye on their growing plants and report back their observations the week after

7. Check up on the celery stalk demonstration. The blue dye should have traveled part way up the stem. Chop off the bottom of the celery plant 1 cm at a time and show how the veins are dyed blue. Explain that plants can draw water up from the ground through **capillary action**; a good way to discuss this is by telling the students to imagine little droplets of water pulling each other up the stem by sticking to each other and to the sides of the veins. Explain that capillary action works even when plants are as tall as redwood trees, which can grow up to 100 meters. In fact, a redwood tree draws up thousands of gallons of water up to its leaves every single day!

8. If it is not a Friday class, leave the celery dipped in the cup overnight (with the teacher's permission) and tell the kids to look at it in the morning – the leaves should be bright blue by the next day!

Clean-up:
Time for section: 5 minutes
Throw Out:
Split open lima beans, plastic knife, celery (if Friday class)
Bring Back:
Blue food coloring, sharpie marker, and leftover paper towels

Enrichment:
If there is time, the control groups could split up to test the effects of gravity or light on the direction of rooting and sprouting (gravitropism and phototropism)

Background:
In order to germinate, almost all seeds require water and a temperature range specific to the plant. Some seeds, especially small seeds, also require light as a condition for germination, since it indicates that the seeds are near the surface. For other (typically larger) seeds, however, light can act as an inhibitory signal, since it may indicate that the seed is not buried deep enough. Air is also a requirement for most seeds, but some seeds (e.g. rice) sprout only when they are submerged underwater.
The capillary action observed in the celery requires no force on the part of the plant. The water is drawn up purely as a result of surface tension in the narrow vascular tubes of the stem. Ordinarily, the water would stop moving up as soon as there is enough mass in the tube for the downward gravitational force to counterbalance the upward-pulling intermolecular forces. In the case of plants, however, the evaporation of water from leaves results in a phenomenon called transpirational pull that sucks up water up in a continual stream: as water evaporates from cells in the interior of leaves, the remaining water recedes into pores and form many concave meniscuses, whose surface tension adds up to generate a tremendous amount of upward force. In this experiment, if the celery leaves were to be heated with a blow dryer, the dye would actually travel up the stem faster!

Sources:
http://en.wikipedia.org/wiki/Seeds
http://en.wikipedia.org/wiki/Transpirational_pull
Images from:
http://www.kidsgardening.com/onlinecourse/PartI5.htm
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Week 10: Owl Pellet Dissection

Objectives:
Students will explore animal anatomy by reconstructing a rodent or bird skeleton found inside an owl pellet while learning about food chains and the eating habits of birds of prey.

Safety Considerations:
Volunteers should supervise students to ensure they never put owl pellets or parts of owl pellets in their mouth. Hand sanitizer or water and soap should be used to wash hands thoroughly when finished. Household bleach in a 1:10 solution should be used to clean work surfaces.

CT Science Standards:

Standard	Definition	Implementation
4.2	Describe how animals, directly or indirectly, depend on plants to provide the food and energy they need in order to grow and survive.	Students brainstorm a food chain from predators to producers. Ex: Sunlight, water → plants (vegetables, fruits, grains) → rodents, birds → birds of prey
3.2 B1.	Describe how different plants and animals are adapted to obtain air, water, food and protection in specific land habitats.	Students learn about the eating habits of birds of prey.
A or B INQ.1	Make observations and ask questions about objects, organisms and the environment.	Students note observations and make predictions on their lab report handouts.
A INQ. 10	Represent information in bar graphs.	Students collaborate as a class to create a bar graph of the animal skeletons in the owl pellets.

Materials:

Item	Per student	Per classroom*
Owl pellets	1 per pair	15
Disposable plates	2 per pair	30
Toothpicks	5	75
Magnifying glasses	1 per pair	15
10% Bleach Solution/Hand Sanitizer		1 large bottle
Owl Pellet Lab Report handout	1	25
Owl Pellet Bone Chart handout	1 per pair	15
White Glue? May be available in classrooms.	1 bottle	15

*For a 25 student classroom

Note: Briefly check the results of last week's plant biology experiment. What did the students observe? Don't spend too much time on this section because the Owl Pellet demonstration is long.

Procedure:

***Note that this protocol may take **longer than 45 minutes**, so adjust discussion time accordingly*

Part 1: Food Chains

Time for this section: 5 minutes

Key Concept: Understand that animals depend on plants indirectly to provide the food and energy they need in order to grow and survive by tracing a food chain from consumers to producers.

Procedure:

1. Ask students to provide examples of predator-prey relationships (ex: cat and mouse, hawk and snake).
2. Ask students to build food chains off of the examples that were provided by classmates. Draw the chains on the board so students can visualize the connections. Explain that food chains show the relationship between producers (plants) and consumers (animals that eat the plants or that eat other animals).

Simple relationships between producers and consumers involved in a barn owl's diet:

Plants, grasses, roots, seeds → mice, rats, gophers, birds

Plants → insects → frogs, birds

Worms → birds, moles

Birds, mice, rats, frogs → weasels

Birds, mice, rats, gophers, frogs, moles, weasels → Barn owls

Part 2: Eating Habits of Owls and Formation of Pellets

Time for this section: 5 minutes

Key Concept: After owls and other birds of prey eat rodents and birds, they regurgitate the indigestible parts of their prey—the hair, feathers, bones, etc.—in the form of an owl pellet.

Procedure:

1. Describe the eating habits of owls to students. Emphasize how adaptations—e.g. strong sharp beaks and specialized digestive organs especially gizzards—determine owls' eating habits.
    a. Like many other birds, owls eat their food whole.
    b. Owls do not have teeth, so they can't chew their food like we do. Instead, they use their strong and sharp beaks to rip their prey apart and swallow the chunks whole.
    c. The food travels down the owl's esophagus to the gizzard.
    d. The owl's gizzard allows the owl to digest its meal slowly by separating soft digestible materials, such as meat, from harder indigestible materials such as bones.
    e. The indigestible materials—the bones, feathers, or fur—are formed into a rounded owl pellet in the gizzard.
    f. The gizzard pushes the pellet back up the esophagus until it is eventually regurgitated so that the owl can have another meal.

g. While the owl is regurgitating the pellet, it appears as though it is having difficulty breathing. Once it ejects the pellet, it settles back into a comfortable position. Sounds uncomfortable, right

<u>Part 3: Owl Pellet Dissection</u>
Time for this section: 30 minutes
Key Concept: Dissecting owl pellets is fun and is another reason why science is cool.

Procedure:
1. Remind students not to put owl pellets in their mouths or near their faces and that they will need to wash their hands thoroughly at the end of the dissection.

2. Have students form pairs. Pass out one Scholastic Owl Pellet Lab Report handout and one Owl Pellet Bone Chart handout to every student. Distribute two disposable paper plates, one magnifying glass, several toothpicks, and one owl pellet to each pair.

3. Ask students to follow along on their Scholastic Owl Pellet Lab Report handout. Tell students to write down their predictions as to the contents of the pellet on the handout. Then ask students to draw and describe the outside of their owl pellet.

4. Demonstrating with an example owl pellet, instruct students to use their toothpicks and gently tease apart the pellet, being careful not to break any of the bones inside it.

5. Separate the bones from the fur or feathers. Take special care when removing the skulls and jawbones, since they are the best way to identify the animals that the owl ate. Group similar bones together. Roll the last bits of fur between your fingers to find little bones or teeth that might have been overlooked.

6. Try to reconstruct the skeletons of the animals. Owls usually eat more than one rodent before regurgitating the remains, so students may be able to find multiple bones that are similar. Circulate among pairs and ask them if they distinguish between the bones of different kinds of rodents based on their size.

7. Ask students to record their findings on their Scholastic Owl Pellet Lab Report handout. Sketch the inside of the owl pellets, describe the details they see, and summarize what they learned about owl eating habits.

8. Poll pairs about what and how many animals they found inside their pellets and draw a bar graph on the board with items like “1 mouse,” “2 mice,” “1 bird,” etc. along the x-axis, and numbers along the y-axis.
<u>Clean-up:</u>

Time for section: 5 minutes

1. Wipe off students' desk surfaces with sanitizing solution. Remind students to wash their hands thoroughly or distribute hand sanitizer.

Throw Out: disposable plates, used toothpicks, dissected owl pellets and remains.
Bring Back: Unused materials, leftover sanitizer solution, and magnifying glasses.

Enrichment:
Have older students use white glue to attach the bones they find inside their owl pellets to the matching bones on the Owl Pellet Bone Chart handout. Younger students can do this as well if there is enough time after introductory lecture.

Background:
The Eating Habits of Owls

Owls are carnivorous and eat a wide variety of animals including: birds, moles, mice, rabbits, skunks, frogs, insects, and much more. Owls' stomachs have multiple parts—the proventriculus, which is the glandular stomach, and the gizzard, which is the muscular stomach.

Pellets

In ornithology, a pellet is the mass of the indigestible portions of a bird's food that some bird species occasionally regurgitate. The contents of a bird's pellet depend on its diet, but can include the exoskeletons of insects, indigestible plant matter, bones, fur, feathers, bills, claws, and teeth. Regurgitation of pellets allows a bird to remove indigestible material from its proventriculus and, in birds of prey and also helps the bird "scour" parts of its digestive tract, including the gullet. Pellets are formed within six to ten hours of a meal in the bird's gizzard (muscular stomach).

Hawk and owl pellets are gray or brown. They can be spherical, oblong or plug-shaped. In large birds, they are one to two inches long, and in songbirds, about half an inch. Many other species produce pellets, including grebes, herons, cormorants, gulls, terns, kingfishers, crows, jays, dippers, shrikes, swallows, and most shorebirds.

The hair, bones and other body parts (such as limbs, skin fragments, and even feces) of rodents found in owl pellets may carry viable rodent viruses and bacteria. Hopefully, the owl pellets used in this demo were sufficiently sterilized/autoclaved by the manufacturer.

Sources:
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http://www.kidwings.com/owlpellets/
http://teacher.scholastic.com/LessonPlans/pdf/oct_nov05/1-2OwlPelletLab.pdf
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