Visit to Tufts
Chapter 1

Renewable Energy and Applied Photonics Lab (REAP)

Dr. Tom Vandervelde, Abby our tour guide, Nicole the scientist, and Ms. Amy
“The general purpose of the lab is to study the interaction of light and matter. We work on photovoltaics (solar cells: convert sunlight to electricity), thermo-photo-voltaics (convert heat to electricity), infrared cameras, and supporting technologies.”

Dr. Tom Vandervelde
"The Photoluminescence set-up is used to characterize the type and quality of light photonic materials produce. The material is stimulated with a laser, then we look at the light it emits. This allows us to design better materials for solar cells and things like LED lighting too."

Dr. Tom Vandervelde
“The demonstration in the cloudy water was to show the refraction, total-internal-reflection, and a couple of other basic optical principles. This tied-in with some of the experiments the kids did in school with lasers and gelatin.”

Dr. Tom Vandervelde
“CryoSim” Cryogenic Thermal Stimulator

The CryoSim has a liquid nitrogen cooling system, a temperature controlled sample stage, a high vacuum chamber, and a blackbody radiation source. It tests how efficient low temperature Thermophotovoltaics (TPV) are. TPV is a device that generates electricity from a heat differential via photons (unit of light). REAP website

According to Dr. Vandervelde, “In this room there were several tools for emitting different broad spectrums of light. There was the solar simulator (the $70,000 light-bulb), which gives off light that is indistinguishable from that of the sun. It is very helpful on cloudy days when we characterize solar cell function.”
“The kids were shown a number of solar cells: Silicon (what is most commonly used on roofs), thin-film (flexible and durable, used in solar powered calculators and on anything that needs to bend), and high efficiency cells III-V (pronounced “three-five” and are used in space and with concentration systems).”

Tom Vandervelde
“There were also several tools there that emit infrared light (i.e. heat) of which the Cryogenic Thermal Simulator is one. This allows us to look at the thermophotovoltaic materials which can convert heat into electricity. This is important, since, for example, 72% of the power from your car’s gasoline is lost in the form of heat. Only 28% actually moves the car forward and powers the electronics. If we could harvest some of that lost heat and convert it back into energy to be used by the car we could double or triple a car’s fuel mileage. This technology is actually useful to convert heat from anything into electricity. The possibilities are endless. The cryo-sim allows us to measure how efficiently our devices are working and helps us to design new devices.”

Dr. Tom Vandervelde
Section 3

Ion Beam Sputter System

Many of the labs use Liquid Nitrogen which is very cold.

LN2 (Liquid Nitrogen) is 80 Kelvin or -315 degrees Fahrenheit or -193 degrees Celsius.
Sputter deposition is a Physical Vapor Deposition (PVD) method of depositing thin films of contacts (such as conducting oxides or gold) by sputtering.

“The purple light (it looks blue on cameras because they measure brightness linearly whereas our eyes measure it logarithmically) was actually an Argon plasma. The plasma is used to deposit thin layers of material onto our samples; such as, thin layers of gold which we use to attach wires and get the electricity out of our solar cells.”

Tom Vandervelde
DANGER. Do not touch. Not only will this kill you, but it will hurt the whole time you’re dying.
Split Junction Solar Concentrator

This machine tests how photovoltaics and thermophotovoltaics work when used together. When you spray water, you can see the green light.

“The light bounces off the thingymabob onto the big mirror and then onto the small mirror through the hole of the big mirror and onto the screen.” JCV
oops.....look what happened after taking pictures in the dark???? Too much light exposure!
Dr. Vandervelde used “a green laser pointer to show the path that sunlight travels. It bounces off of the large primary reflector, then off the secondary reflector, and finally is absorbed by the photovoltaic cell behind the primary reflector. This type of mirrored set-up is referred to as a Cassegrain reflector. The sprayed water gave us something for the laser light to scatter off of, so you could see its path. The incident sunlight that hits the large primary mirror follows that path and is concentrated down to an area of about 1 cm. in diameter.”

Dr. Vandervelde
Chapter 2

Green Energy & Nanostructured Electronics Lab
Dr. Matthew Panzer is working on creating the next generation of solar cells using materials like polymers and organic molecules.

Dr. Panzer is an important researcher, but he is also a great teacher. In 2011, Dr. Panzer was elected “Professor of the Year” by the Tufts Student Body.
Section 1

Polymers

Adam Visentin, Ariel Horowitz, and Stephanie Flores (who showed us the polymers)
Dr. Panzer uses a foot pedal to lower the pressure of air inside the chamber so that he can push his hand in the rubber glove into the chamber of nitrogen rich air. Once his arm is inside, he can pick up objects and work with materials inside the chamber.

Movie 2.2 Using Rubber Gloves in Chamber

In this lab, everyone needed to wear safety goggles.

Dr. Panzer talked to the kids about the vials they were passing around. The various substances in the vials have different properties; some are squishy and others are hard.
Changquiong Zhu from China was very excited to talk about her research.

“The solar cells that Changquiong is making are made of earth-abundant materials. This is important, because if you want to make a large number of solar panels, you want to make them out of materials that aren’t rare.”

Dr. Tom Vandervelde
Section 3

Oxygen Free Chamber
Dr. Panzer “makes the organic PV in the oxygen free environment because they degrade in oxygen, so they have to be made without oxygen present then sealed behind glass so oxygen does not get to them.” He also makes high efficiency batteries.” Dr. Tom Vandervelde.

“You open the thingy with your hand, then you let the air release, then you put nitrogen in, and you do it again 3x (again and again) until there’s no air, and then you put your arm into the big glove and you open the thing and get the thing you want which has no oxygen air -- only nitrogen.” JCV
Chapter 3
Ultrafast Nonlinear Optics & Biophotonics Lab
According to Chinese legend, silk was first discovered in 2640 BC by XiLingJi, the fourteen year old wife of China's third Emperor - the so called "Yellow Emperor" - HuangDi.

It is said that XiLingJi was having tea beneath a mulberry tree in the palace gardens, when a cocoon fell from the tree into her cup of hot tea. She and her handmaidens were astonished to see the cocoon start to unravel, revealing a long delicate thread. XiLingJi was so delighted by its beauty and strength that she had thousands of cocoons collected and then wove them into a robe for the Emperor.  

http://www.silk100.com/story_of_silk.html
Section 1

Silk - used for optics
Dr. Benedetto Marelli works in the Omenetto (Ultrafast Optics and Biophotonics, technological biomaterials) lab and is interested in using silk as a material for photonics and other high tech applications.

His research is interdisciplinary and involves links across physics, engineering, biology, medicine, material sciences, and chemistry.

He hopes eventually that the silk can be used to deliver medicine safely, and dissolve in the body.  From Omenetto Lab website

**Movie 3.2 Plastic vs. Silk optics dissolving in Water**

The edge is thicker so takes longer to dissolve.
“Some butterfly wings don’t have pigment to reflect the colors in light...the butterfly has a forest of nano-trees, which captures white light, filters and selects it and reflects the blue color.”

Dr. Omenetto

JCV says, “The wings look blue but are not really blue; inside they are brown.”

Benedetto Marelli shows us butterfly wings under magnification.
Section 3

Plastic and Silk Optics
From a thin piece of plastic, you can project a green light that goes through a lenses to project a variety of images, including patterns of light, a radiation sign, a keyboard, words, a photograph, etc.

“The silk can be used to make implantable circuits that can be put into the human body. The silk can also act as an internal bandage to help the body heal and then just dissolve over time, so you don’t have to worry about removing it. You can make a solar cell out of them (i.e. the whole tent can be a solar cell).”

Dr. Tom Vandervelde
Chapter 4

Ice Cream

Liquid Nitrogen + Cream + Sugar + Oreo Cookies or Vanilla Extract = Cookies and Cream Ice Cream or Vanilla Ice Cream with yummy sprinkles and toppings
Let it Snow, Let it Snow, Let it Snow

Ooohhh. I can’t wait to eat this very yummy ice cream!!!!

YUM!!!!

Audio 4.2 Let it Snow, Let it Snow, Let it Snow

I scream
You scream,
We all scream for Ice Cream!
Movie 4.2 Using Liquid Nitrogen

Movie 4.1 Look at the Vapors

Movie 4.3 Mixing ingredients

Movie 4.4 Yummy!!!
THANK YOU
DR. VANDERVELDE!!!

Audio 4.3 JCV
Thank You
Audio Recording

Audio 4.4 Rudolph the Red-nosed Reindeer

ibook created by JCV Acera School with help of mom PCL