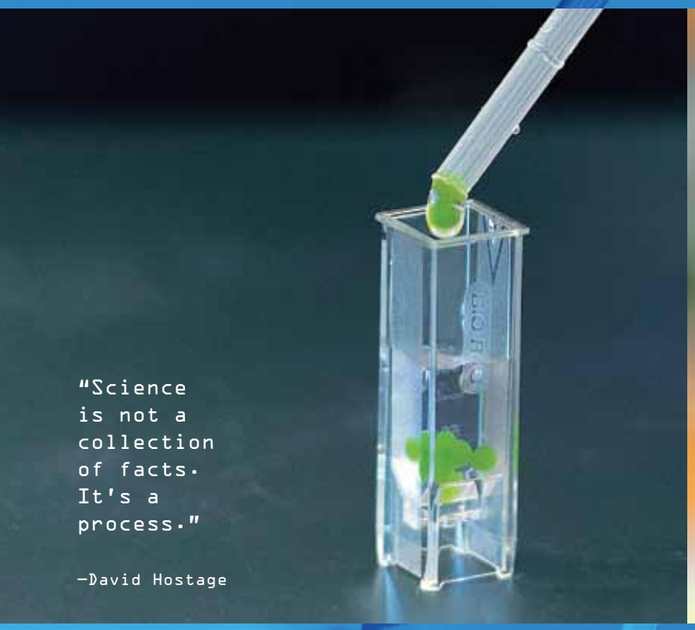
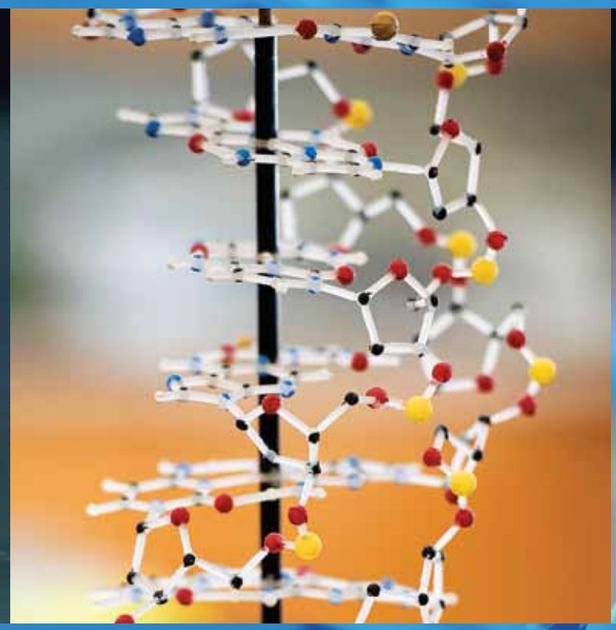
By Kaitlin Thomas Orfitelli
Photographs by Robert Falcetti

growing scientists



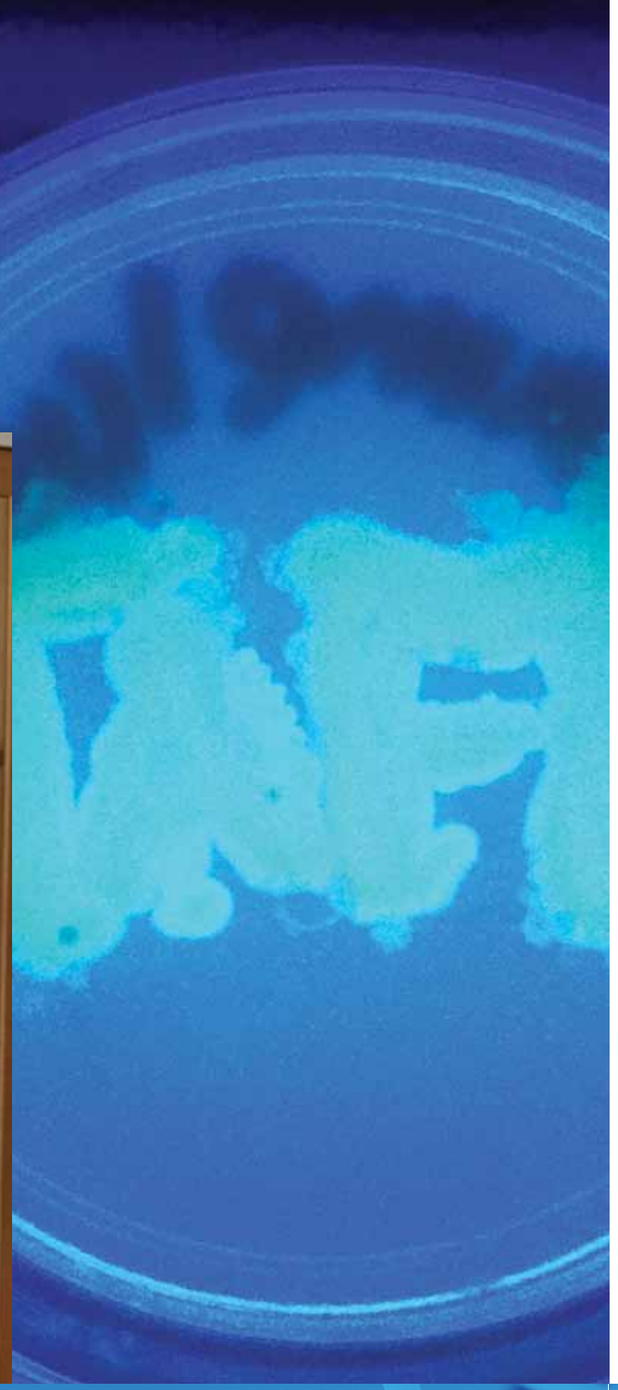
"Science is not a collection of facts. It's a process."

—David Hostage



Taft science students have been tackling independent tutorials in quantum mechanics, neuroscience, the controlled release of anti-cancer drugs, and human echolocation this year. "The level of science taught here now is above and beyond what the school has seen in its history," says Academic Dean Jon Willson '82.

Just as the sophistication of science studies has grown, so too has the engagement in science courses. An overwhelming majority of Taft students graduate with at least four years of science, with many completing the equivalent of five years. Behind all of this work is a faculty that challenges students with the goal of cultivating independent, scientific thinkers.



Ezra Levy '15 spent time this past year in Taft's labs working on a research project to create autoluminescent plants. This summer he plans to continue learning about plants and genetics as an intern at the New York Botanical Garden.

Last summer Ezra Levy '15 was visiting a rural orphanage in Mozambique when he had an idea. "We were talking about the dangers of living in such a remote area without a reliable light source at night," he remembers, "and I realized maybe it was something I could help with."

The way he could help? Science.

Mozambique, where Levy lived for much of his childhood, is mostly without power—as of 2010, 85 percent of the population had no access to electricity. At night people are vulnerable to inadvertently wandering too close to lakes and rivers and falling prey to crocodiles. Levy's idea: create autoluminescent plants to serve as trail markers, essentially creating glowing paths in the darkness.

Since his trip to Mozambique last summer, Levy has become fluent in a science vocabulary not typical among high school students as he has delved into an independent tutorial focused on selectively transplanting autoluminescent genes into plants.

With the guidance of faculty advisor Laura Monti '89, he spent the year researching the genetic makeup of fireflies, learning the intricacies of the luciferin luciferase reaction, and doing hands-on lab work.

"We transformed bacteria with genes, and that went very well," Levy says of his work in the lab. "We created plates of green glowing *E. coli*. They were dim, but it did work."

Bespectacled and soft-spoken, Levy talks about the challenges he has faced with his project and his newfound appreciation for the painstaking process of research. "When considering something like this you have to think of every possible variable," he says. "How big is the gene, where will it fit, what plant would be a good match? What is the best source of autoluminescence? Is there a need for a trigger mechanism? Would the force of the wind be enough to trigger the plant to glow? The questions just keep growing."

The focus of Levy's project shifted over the year as he came to realize that he wouldn't have the time or the funding to execute such an ambitious project before his graduation. Much of his final semester was spent drafting a comprehensive grant proposal, synthesizing his ideas and research challenges.

One of the more important things Levy has gained at Taft, he says, has been exposure to the world of research—discussing historically significant experiments both inside and outside of science classes, and engaging teachers and fellow students in discussions about contemporary science and research trends.

"Taft has amassed a group of individuals who are really intelligent," Levy says of the Science Department faculty, "but more than that they are great educators." Taking AP Chem as a sophomore with Mr. Hostage was tough, he says. Levy had just moved to the U.S. It was a whole new culture and curricular system. "Mr. Hostage certainly did not spoon-feed us all of the information we needed," Levy says. "He provided us with all of the resources we needed to study and to succeed in his class and on the AP exams. And the way he motivated me to slowly but surely become a more independent learner has been beneficial beyond belief."

That idea of cultivating independent, scientific thinkers is at the core of the Science Department's philosophy.

"The end goal is to give students self motivation, creativity, persistence—we give them the framework and resources to do their work," says Jim Lehner, head of the department. "We try not to be overwhelming as far as guidance—and we get good results."

E. coli with GFP (green fluorescent protein) expression, a green glowing protein seen over a UV light. Students in Amanda Benedict's AP Biology class did this lab during the spring semester.

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Srinidhi Bharadwaj '15 plans to continue with intensive lab work while at Columbia University next year. It's not lost on her that Thomas Morgan—credited for pioneering the use of fruit flies in genetics research—had a famous "fly room" at Columbia.

Part of the reason that the level of student work has grown so drastically in the past decade is the sequencing of the curriculum. With the move to a physics-first curriculum, Taft has been able to offer chemistry and biology in the 10th and 11th grades, respectively, and post–AP courses (which were not part of the curriculum just a few years ago) are now standards. Post–AP Biology, for example, has grown since its inception in 2012, with 19 students enrolled this year in a class led by Laura Monti '89 and fellow faculty member Michael McAloon. AP and post–AP work extends across the scientific disciplines and across the student body, with lower mids now taking AP Physics.

Just as there are compelling narratives like Levy's about the sophisticated science work Tafties are doing, so too is there an impressive story as far as engagement of girls in science at Taft. In AP Biology, for example, 32 of the 51 students are girls. In Post–AP Biology, 10 out of the 19 students are girls.

One of those girls involved in the highest levels of science is Srinidhi Bharadwaj '15, a senior who Monti describes as a student with significant firepower—the kind of student who seeks out graduate-level textbooks out of innate curiosity.

Bharadwaj has taken five independent tutorials at Taft (three in biology and two in chemistry), in addition to AP classes in physics, chemistry, and biology as well as in BC Calculus, Statistics, English Language and Composition, Computer Science, and U.S. History. She likes the flexibility that independent tutorials allow—and the fact that she can design and pursue the project she's most interested in.

"Before 11th grade, I was all brain, all the time," Bharadwaj says. "I was studying neuroscience and really thought that was where my interest would stay. That was before I got into flies."

For the past two years, Bharadwaj has been researching the effects of inbreeding on the reproductive fitness of wild and captive populations of the fruit fly, *Drosophila melanogaster*. Armed with homemade ambrosia of bananas and honey, Monti caught a couple of wild fruit flies by Mac Quad. She and Bharadwaj ordered additional fruit flies from a lab to serve as the project's captive population.

"I had no idea what I was doing at first," Bharadwaj says about the project. "Ms. Monti's philosophy with me was that she would teach me a little bit of what to do and then she wanted me to mess up as many times as I needed to and figure out how to do it myself. I messed up a lot."

One time, Bharadwaj remembers, she forgot to check the meter on the CO_2 she was using as an anesthetic on the flies. The gas ran out before she had completed her work, the flies woke up, and they all flew away.

"You learn to deal with failure over and over and over again," she says. "You have to learn to work meticulously for extended periods of time. If I was in a bio class and missed a detail, I might lose a point or two. But here, if I mess up in the lab, I would see all of my effort go to waste. It makes you meticulous. But at the same time, it makes you comfortable with failure. You're going to fail sometimes—and then you just have to start over again, to keep going."

Bharadwaj's lab work included stressing the flies to see how the captive and wild individuals responded differently. She did "chill coma" tests (in which she would record data on how quickly the flies could recover after three hours in subzero temperatures) and used the chemistry lab's desiccation chamber to see how vulnerable the flies were to arid conditions.

Bharadwaj became good—really good—at the lab work. She modestly shrugs off her ability to differentiate between male and female fruit flies with the naked eye. "After a while I would just close my eyes and see fruit flies," she says with a chuckle. "I had a dream about flies once. I'd see fly larvae—the structure of it—in the shapes of my food. It was really all-encompassing."

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Independent tutorials

at Taft extend to chemistry and physics as well. Faculty member Jim Mooney has, for the past three years, mentored students who finish AP Physics C early by offering independent tutorials in quantum mechanics.

Taking students as far as they can go in science has led to a full schedule of extracurricular science opportunities in addition to students' already packed formal schedules. Mooney, for example, works with students preparing for the Trinity College Robotics Competition during afternoons between other commitments and on weekends as an extracurricular activity. Four teams of students work for several months to build the robots, which they then bring to compete against teams from all over the world. Each team is given the task of programming their robots to move autonomously through an arena, find a candle, and extinguish it before exiting.

Mooney also takes students to the Yale Physics Olympics each fall, where high school students face a series of challenges designed by Yale's Physics Department. Fifty or so teams compete, spending a day measuring and constructing and sometimes grappling with theoretical questions. Taft students have done very well in the competition, having twice come in first place.

Tafties have also traveled to the University of Connecticut each spring for the past five years to participate in the Science Olympiad, a nationwide science tournament. The competition for that tournament extends across the science curriculum, with problems ranging from the very concrete (identification of fossils and rocks, for example) to the very theoretical (including calculations for complicated astronomy questions). "Last year, we came in third, which was great," Mooney says. "We are competing against schools that have entire programs geared toward preparing for this event."

Down the hall from Mooney's classroom, faculty member David Hostage ushers students through post–AP Chemistry and independent tutorials in chemistry. Hostage looks around his classroom, the long tables set up with stations for students to do a titration lab. "I like having a messy lab—I like having a lab that's being used," he says. "It's OK to have labs fail. It's what science is all about—you have an idea, you try it, it fails, you rethink it, you try again. Science is not a collection of facts. It's a process."

Hostage's post–AP class spends the fall studying organic chemistry not so that they can be waived out of the class in college, he explains, but so that they will feel comfortable with the material at the college level. "It's a very difficult college course used as a weeding-out process for pre-med majors," Hostage says. "I want my kids to get to college and feel comfortable with the material. Those are the students who will get an A on the first exam in their college organic chemistry class and not drop it three weeks in." In the spring semester, Hostage's class studies biochemistry, thermodynamics, and materials science (the interface between modern chemistry and modern physics), before moving on to ceramics and rounding out the year having some fun with chemistry and popular fiction.

The science curriculum extends beyond the big three of physics, bio, and chem, of course. Science courses on medical ethics and forensics help keep students who are not as strong in science engaged in scientific thought, giving them confidence with scientific vocabulary and reasoning. Similarly, aquaculture, oceanography, and environmental science courses are well attended, with three or four sections of AP Environmental Science being offered each academic year.

"The school does a really great job of preparing students to be critical thinkers," says science teacher Dr. Amanda Benedict. "Part of the strength of the Science Department is that there is great care paid to teaching the lower mids, mids, and the students whose primary focus is not science—it's not just the science superstars who are taught well here. Our talented faculty offers broad electives that inspire curiosity in all kinds of students."

Room to Grow

Lab work is hard—it takes a lot of planning, space, and equipment.

The nearly 48,000-square-foot Lady Ivy Kwok Wu Science and Mathematics Center is home to all things science and math—including an aquaculture lab, a robotics room, an observable honeybee colony, and a telescope platform with a reflecting telescope.

The building (known as "Wu") currently houses project rooms in which students get hands-on experience working with high-tech equipment such as a fluorescent microscope and a PCR machine, which is capable of replicating a single copy of DNA into a million copies within four hours.

Science Department Head Jim Lehner hopes that physics students soon will have similar space to use the school's 3D printer and digitizer. "We'd like to continue to expand our hands-on offerings," he says, "so when students get to the next level they can really get in-depth experience with advanced technology. What an advantage that would give them."

Pen Naviroj '15 works with physics teacher Jim Mooney in a compound machine class.

Lexi Walker '16 and Jona Vithoontien '17 use a system of levers to determine the ratio of two unknown weights as they practice for the Science Olympiad.

Laura Monti '89 (right) works with Jenna Longo '15 (center) and Megan Stone '15 (far left) in Post–AP Biology class.

Watching a reaction in Accelerated Chemistry class.
PETER FREW '75