The California Tech

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Bare Bones: Making Bones Transparent

Lori Dajose
Caltech Media Relations

This article is adapted from a story that was originally published online at caltech.edu.

Ten years ago, the bones currently in your body did not actually exist. Like skin, bone is constantly renewing itself, shedding old tissue and growing it anew from stem cells in the bone marrow. Now, a new technique developed at Caltech can render intact bones transparent, allowing researchers to observe these stem cells within their environment. The method is a breakthrough for testing new drugs to combat diseases like osteoporosis.

The research was done in the laboratory of Viviana Gradinaru (BS '05), assistant professor of biology and biological engineering and a Heritage Medical Research Institute Investigator. It appears in a paper in the April 26 issue of Science Translational Medicine.

In healthy bone, a delicate balance exists between the cells that build bone mass and the cells that break down old bone in a continual remodeling cycle. This process is partially controlled by stem cells in bone marrow, called osteoprogenitors, that develop into osteoblasts or osteocytes, which regulate and maintain the skeleton. To better understand diseases like osteoporosis, which occurs when loss of bone mass leads to a high risk of fractures, it is crucial to study the behavior of stem cells in bone marrow. However, this population is rare and not distributed uniformly throughout the bone.

"Because of the sparsity of the stem cell population in the bone, it is challenging to extrapolate their numbers and positions from just a few slices of bone," says Alon Greenbaum, postdoctoral scholar in biology and biological engineering and co-first author on the paper. "Additionally, slicing into bone causes deterioration and loses the complex and three-dimensional environment of the stem cell inside the bone. So there is a need to see inside intact tissue."

To do this, the team built upon a technique called CLARITY, originally developed for clearing brain tissue during Gradinaru's postgraduate work at Stanford University. CLARITY renders soft tissues, such as brain, transparent by removing opaque molecules called lipids from cells while also providing structural support by an infusion of a clear hydrogel mesh. Gradinaru's group at Caltech later expanded the method to make all of the soft tissue in a mouse's body transparent. The team next set out to develop a way to clear hard tissues, like the bone that makes up our skeleton.

In the work described in the new paper, the team began with bones taken from postmortem transgenic mice. These mice were genetically engineered to have their stem cells fluoresce red so that they could be easily imaged. The team examined the femur and tibia, as well as the bones of the vertebral column; each of the samples was about a few centimeters long. First, the researchers removed calcium from the bones: calcium contributes to opacity, and bone tissue has a much higher amount of calcium than soft tissues. Next, because lipids also provide tissues with structure, the team infused the bone with a hydrogel that locked cellular components like proteins and nucleic acids into place and preserved the architecture of the samples. Finally, a gentle detergent was flowed throughout the bone to wash away the lipids, leaving the bone transparent to the eye. For imaging the cleared bones, the team built a custom light- sheet microscope for fast and high-resolution visualization that would not damage the fluorescent signal. The cleared bones revealed a constellation of red fluorescing stem cells inside.

The group collaborated with researchers at the biotechnology company Amgen to use the method, named Bone CLARITY, to test a new drug developed for treating osteoporosis, which affects millions of Americans per year.

"Our collaborators at Amgen sent us a new therapeutic that increases bone mass," says Ken Chan, graduate student and co-first author of the paper. "However, the effect of these therapeutics on the stem cell population was unclear. We reasoned that they might be increasing the proliferation of stem cells." To test this, the researchers gave one group of mice the treatment and, using Bone CLARITY, compared their vertebral columns with bones from a control group of animals that did not get the drug. "We saw that indeed there was an increase in stem cells with this drug," he says. "Monitoring stem cell responses to these kinds of drugs is crucial because early increases in proliferation are expected while new bone is being built, but long-term proliferation can lead to cancer."

The technique has promising applications for understanding how bones interact with the rest of the body.

"Biologists are beginning to discover that bones are not just structural supports," says Gradinaru, who also serves as the director of the Center for Molecular and Cellular Neuroscience at the Tianqiao and Chrissy Chen Institute for Neuroscience at Caltech. "For example, hormones from bone send the brain signals to regulate appetite, and studying the interface between the skull and the brain is a vital part of neuroscience. It is our hope that Bone CLARITY will help break new ground in understanding the inner workings of these important organs."

The paper is titled "Bone CLARITY: Clearing, imaging, and computational analysis of osteoprogenitors within intact bone marrow." Other Caltech coauthors include incoming graduate students Tatyana Dobreva and David Brown. Helen J. McBride and Rogely Boyce of Amgen also coauthored the paper. Funding was provided by the National Institutes of Health, the Presidential Early Career Award for Scientists and Engineers, the Heritage Medical Research Institute, the Shurl & Kay Curci Foundation, the Amgen Chem-Bio-Engineering Awards, the Pew Charitable Trusts, the Kimmel Foundation, and the Caltech-City of Hope Biomedical Research Initiative. Alon Greenbaum is a Good Ventures Fellow of the Life Sciences Research Foundation.

Researchers discover first three-dimensional quantum liquid crystal

Whitney Clavin
Caltech Media Relations

This article is adapted from a story that was originally published online at caltech.edu.

Physicists at the Institute for Quantum Information and Matter at Caltech have discovered the first three-dimensional quantum liquid crystal—a new state of matter that may have applications in ultrafast quantum computers of the future.

"We have detected the existence of a fundamentally new state of matter that can be regarded as a quantum analog of a liquid crystal," says Caltech assistant professor of physics David Hsieh, principal investigator on a new study describing the findings in the April 21 issue of Science. "There are numerous classes of such quantum liquid crystals that can, in principle, exist; therefore, our finding is likely the tip of an iceberg."

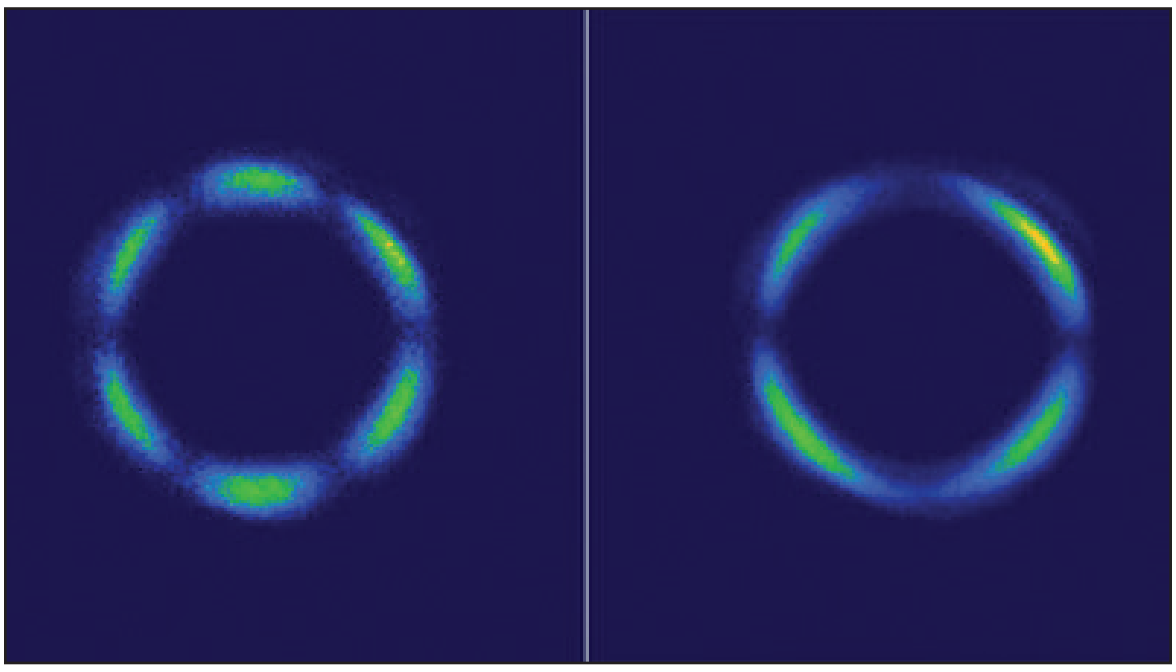
Liquid crystals fall somewhere in between a liquid and a solid: they are made up of molecules that flow around freely as if they were a liquid but are all oriented in the same direction, as in a solid. Liquid crystals can be found in nature, such as in biological cell membranes. Alternatively, they can be made artificially—such as those found in the liquid crystal displays commonly used in watches, smartphones, televisions, and other items that have display screens.

In a "quantum" liquid crystal, electrons behave like the molecules in classical liquid crystals. That is, the electrons move around freely yet have a preferred direction of flow. The first-ever quantum liquid crystal was discovered in 1999 by Caltech's Jim Eisenstein, the Frank J. Roshek Professor of Physics and Applied Physics. Eisenstein's quantum liquid crystal was two-dimensional, meaning that it was confined to a single plane inside the host material—an artificially grown gallium-arsenide-based metal. Such 2-D quantum liquid crystals have since been found in several more materials including high-temperature superconductors. These are materials that conduct electricity with zero resistance at around –150 degrees Celsius, which is warmer than operating temperatures for traditional superconductors.

John Harter, a postdoctoral scholar in the Hsieh lab and lead author of the new study, explains how 2-D quantum liquid crystals behave in strange ways. "Electrons living in this flatland collectively decide to flow preferentially along the x-axis rather than the y-axis even though there's nothing to distinguish one direction from the other," he says.

Now Harter, Hsieh, and their colleagues at Oak Ridge National Laboratory and the University of Tennessee have discovered the first 3-D quantum liquid crystal. Compared to a 2-D quantum liquid crystal, the 3-D version is even more bizarre. Here, the electrons not only make a distinction between the x-, y-, and z-axes, but they also have different magnetic properties depending on whether they flow forward or backward on a given axis.

Continued on page 3



These images show light patterns generated by a rhenium-based crystal using a laser method called optical second-harmonic rotational anisotropy. At left, the pattern comes from the atomic lattice of the crystal. At right, the crystal has become a 3-D quantum liquid crystal, showing a drastic departure from the pattern due to the atomic lattice alone.
Photos Courtesy of the Hsieh Lab/Caltech

IN THIS ISSUE

Caltech Y Column

CALTECH Y

Upcoming Events

Poster Making for March for Science

Thursday | April 20th | 6:00 - 8:00 PM | Avery House Courtyard/ Dining Hall

Join teachers preparing signs for the LA and Pasadena science marches while enjoying the talents of Magic Castle magician Rmax! Rmax will do strolling magic during the sign-making and will have a stage performance to round out the night! Refreshments and Sign-Making Materials Provided.

Caltech Y Spring Friends Dinner with Dr. Charles Elachi

"The Golden Age of Exploration"

Thursday | April 20th | 6:00 PM | The Athenaeum | $85 pp

Please join us for our upcoming Friends Dinner with our guest speaker Dr. Charles Elachi who will be speaking on the topic:

"The Golden Age of Exploration"

JPL missions have visited every planet in our Solar System. Over the last fifteen years, three rovers have explored Mars in coordination with a number of orbiters. Samples have been brought back from a comet tail and the solar wind. Saturn and its satellites have been studied extensively with Cassini. Planets around neighboring stars were discovered. Many new insights in our planet's environment have been acquired.

Dr. Elachi will describe, from first-hand experience, the excitement and impact of these discoveries and the challenges and risks for the next 15 years.

Limited spots available, please call the Caltech Y office on 626 395 6163 to secure your seat!

March for Science

Saturday | April 22nd | Pasadena and LA

Join Caltech students in demonstrating support for science and science funding in the US. Groups of students will be attending both the Pasadena March for Science and the LA March for Science. Also look out for March for Science t-shirts and a banner that you can sign outside of Chandler during lunch.

The Pasadena March will start at Beckman Lawn at 8:00 am and walk to Memorial Park. Visit www.facebook.com/MarchForSciencePasadena for more details.

Students wanting to attend the LA March can meet on campus at the parking lot north of the Beckman Auditorium and receive a free shuttle to the Gold Line, more details at https://www.facebook.com/events/366097583784693/. For general information on the LA March see http://marchforsciencela.com/.

Your world awaits... will you act?

The Caltech Y Advocating Change Together (ACT) Award

Applications are due by Friday, April 21st no later than noon

Visit www.caltechY.org/programs_services/commservice/ACT/index.php for applications and more information

Optional Info Dinner – Tues. April 11th - 6 pm - Hosted By Tom Mannion. RSVPs by April 7th to http://tinyurl.com/Y-Awards

Got an issue or cause that warrants attention? Explore the issue - by attending a conference, training, or workshop, or choosing to immerse yourself with a mentor or organization that is addressing your issue – then plan some programs to raise awareness on campus. Awardees can receive up to $4500 to cover expenses for their educational experience, including registration and program fees, travel, lodging, food, and incidentals.

Local, national, or global travel - as well as one day, multi-day, and even multi-week experiences - are all eligible. The Caltech Y ACT Award, made possible with generous support of the Caltech Employees Federal Credit Union, offers students an opportunity to pursue an issues through service or advocacy.

Stop by the Caltech Y or contact us to learn more about this exciting opportunity! Contact Greg Fletcher gregf@caltech.edu or Liz Jackman ljackman@caltech.edu for more information.

The Studenski Memorial Award

Proposals are due Friday, April 21st no later than noon

Visit www.caltechY.org/programs_services/areas/Studenski/index.php for proposal guidelines

Optional Info Dinner – Tues. April 11th - 6 pm - Hosted By Tom Mannion. RSVPs by April 7th to http://tinyurl.com/Y-Awards

Are you wondering about the next step in your life? Have you reached a crossroad where you would benefit from an opportunity to explore? Would a trip, an opportunity to volunteer with an organization, or a chance to try a new skill or interest this summer help you gain clarity? If you answered yes to any of these questions, then the Studenski Award might be for you.

The Studenski Memorial Award is a grant of up to $6000 established in the memory of Paul Studenski, a Caltech student who was killed in an automobile accident while traveling across the United States in 1974. It is awarded to a Caltech undergraduate who, having reached a crossroads in life, would benefit from a period away from the academic community to obtain a better understanding of self and to explore possible directions for the future.

Studenski proposals (1 to 2 pages maximum) are due Friday, April 21st no later than 12:00 noon to caltechY@caltech.edu (in word format). Contact Athena Castro athena@caltech.edu or Greg Fletcher gregf@caltech.edu if you have questions.

Caltech Y Photo Contest

Deadline May 10th

The Caltech Y Photo Contest is on again! If you have participated in a Caltech Y program and are a current student, submit your photos for a chance to win. We're giving a $100 prize to the winner of each of the five photo contest categories. The 5 categories come from the Caltech Y pillars of:

Perspective
Adventure
Service
Civic Engagement
Leadership

Photos should demonstrate the pillar in action. Photos of people are preferred, but exceptional scenic pictures will also be accepted. After the deadline, we select the finalists, upload them to our Facebook page, and our fans vote for their favorites to determine the winners. Winners will be announced on June 1st.

Deadline to Submit Photos: Wednesday, May 10, 2017

Hathaway Sycamores

Every Wednesday | 6:00 - 8:00 PM | Highland Park

Volunteer at Hathaway Sycamores, a groupthatsupportslocalunderprivileged but motivated high school students. There are a variety of ages and subjects being tutored.The service trip includes about an hour of travel time and 1.5 hours of tutoring. Transportation is included.

For more info and to RSVP email Sherwood Richers at srichers@tapir.caltech.edu. Eligible for Federal Work Study.

Pasadena LEARNS

Every Friday | 3:00 - 5:00 PM | Pasadena

Come volunteer at Madison and Jackson Elementary School! We are partnered with the Pasadena LEARNs program and work with their Science Olympiad team or do regular tutoring along with occasional hands-on science experiments. Transportation is provided. For more information and to RSVP, contact azhai@caltech.edu. Eligible for Federal Work Study.

Mentoring For Life

Every Monday | 3:30pm | Wilson Middle School Pasadena

Stressed out by college life? Step outside the Caltech bubble and mentor tweens who've never even thought about college. Things you could do: Build a baking soda and vinegar volcano, read a book aloud, play sports or board games, teach the alphabet of another language, do a craft. Having a mentor makes an at-risk student 55% more likely to attend college, 78% more likely to volunteer regularly, and 130% more likely to hold a leadership position. Interested? If you have 180 seconds, you can watch this video and be inspired. If you have an hour a week, you can mentor someone and be their inspiration. If you feel unqualified, don't worry. Ultimately, mentoring is about being a consistent, dependable friend—not a surrogate parent or psychiatrist. To get started, contact noelle@caltech.edu.

Beyond the Y

Caltech Earth Week 2017 Events

April 15-22, various locations

Join the Caltech community for a week of events April 15-22 to celebrate Earth Day! There will be theater performances, opportunities to engage with local environmental organizations, and lunchtime speaker seminars on a variety of topics ranging from environmental justice to urban forestry. Visit www.earthday.caltech.edu for the full schedule of events!

New crystals may play role in computing

Continued from page 1

"Running an electrical current through these materials transforms them from nonmagnets into magnets, which is highly unusual," says Hsieh. "What's more, in every direction that you can flow current, the magnetic strength and magnetic orientation changes.

Physicists say that the electrons 'break the symmetry' of the lattice."

Harter hit upon the discovery serendipitously. He was originally interested in studying the atomic structure of a metal compound based on the element rhenium. In particular, he was trying to characterize the structure of the crystal's atomic lattice using a technique called optical second-harmonic rotational anisotropy. In these experiments, laser light is fired at a material, and light with twice the frequency is reflected back out. The pattern of emitted light contains information about the symmetry of the crystal. The patterns measured from the rhenium-based metal were very strange—and could not be explained by the known atomic structure of the compound.

"At first, we didn't know what was going on," Harter says. The researchers then learned about the concept of 3-D quantum liquid crystals, developed by Liang Fu, a physics professor at MIT. "It explained the patterns perfectly. Everything suddenly made sense," Harter says.

The researchers say that 3-D quantum liquid crystals could play a role in a field called spintronics, in which the direction that electrons spin may be exploited to create more efficient computer chips. The discovery could also help with some of the challenges of building a quantum computer, which seeks to take advantage of the quantum nature of particles to make even faster calculations, such as those needed to decrypt codes. One of the difficulties in building such a computer is that quantum properties are extremely fragile and can easily be destroyed through interactions with their surrounding environment. A technique called topological quantum computing—developed by Caltech's Alexei Kitaev, the Ronald and Maxine Linde Professor of Theoretical Physics and Mathematics—can solve this problem with the help of a special kind of superconductor dubbed a topological superconductor.

"In the same way that 2-D quantum liquid crystals have been proposed to be a precursor to high-temperature superconductors, 3-D quantum liquid crystals could be the precursors to the topological superconductors we've been looking for," says Hsieh.

"Rather than rely on serendipity to find topological superconductors, we may now have a route to rationally creating them using 3-D quantum liquid crystals" says Harter. "That is next on our agenda."

The Science study, titled "A parity-breaking electronic nematic phase transition in the spin-orbit coupled metal $Cd_2Re_2O_7$," was funded by the U.S. Department of Energy, the U.S. Army Research Office's Defense University Research Instrumentation Program, the Alfred P. Sloan Foundation, the National Science Foundation, and the Gordon and Betty Moore Foundation.

Midterm Progress Grades: The Elusive Indicator

Timothy Liu
ARC Chair

Many professors are unaware their students want midterm progress grades; students can be proactive and ask for them.

A recent study done by the Academics and Research Committee (ARC) found that the average student sees midterm progress grades in only 45% of the courses they are taking. Midterm progress grades are useful tools that give students feedback on how they're doing in a class. They are also critical for students who are considering dropping a course. Given how useful midterm grades can be, students are often puzzled and frustrated by how inconsistently they are posted. Based on discussions with teaching faculty across several divisions, the ARC found that many professors are simply unaware that students want to see midterm progress grades. The most effective step students can take is to simply ask their professors to post midterm grades or a grade distribution.

During Week 9 of fall term, the ARC sent a survey to the undergraduate population to gather information on midterm progress grades. A summary of the survey results can be viewed at arc.caltech.edu under the "Survey Data" link. The ARC asked students how many academic classes on grades they were taking, and of these how many classes posted midterm progress grades, either through REGIS or some other electronic service. Freshmen on pass fail were excluded from the survey. Out of 262 responses, the ARC found that students on average see midterm progress grades in 45% of the courses they are enrolled in. The survey also sought to find if students are getting their graded work returned. Students reported getting all of their work through week 6 returned in 75% of their classes. In many classes, the problem isn't that students don't get their graded work back. Instead, students often have a poor understanding of how they are doing compared to their peers.

In March of 2017, several ARC members presented these findings to the Council on Undergraduate Education (cue.caltech.edu). The CUE is composed of faculty members from several divisions, and includes three undergraduates (Timothy Liu, Gabby Tender, and Jay Palekar). When the members of the CUE were asked why professors don't post midterm grades, the most common answer was that faculty don't realize they are useful to students. There is a well understood expectation that faculty should post midterm grade deficiencies for students who are on track to receive a C- or lower. However, faculty members are not actively instructed or encouraged to post midterm grades for all students. Professor Joe Shepherd noted that many faculty have the impression that only deficiencies need to be posted.

For some classes, it may be difficult to provide an accurate midterm letter grade. Professor Gil Refael pointed out that many of his classes have only sets and a final, and a midterm grade would be based only on sets. Since set scores tend to skew towards perfection, a midterm grade could have little correlation with a final letter grade. In other cases, it may be difficult to come up with a midterm letter grade for small classes or project-based classes. However broad feedback measures other than a letter grade can be just as helpful. Some professors post a histogram with the distribution of class performance, while other classes publish the mean, first quartile, and third quartile scores.

Midterm progress grades are useful tools for students. Even in classes that promptly return graded work, students want to know how they are performing compared with their peers. Students who want midterm progress grades or score distributions should get into the habit of asking their professors to post them. For professors, a midterm grade or a simple histogram of scores is a straightforward way to help students gauge their class performance.

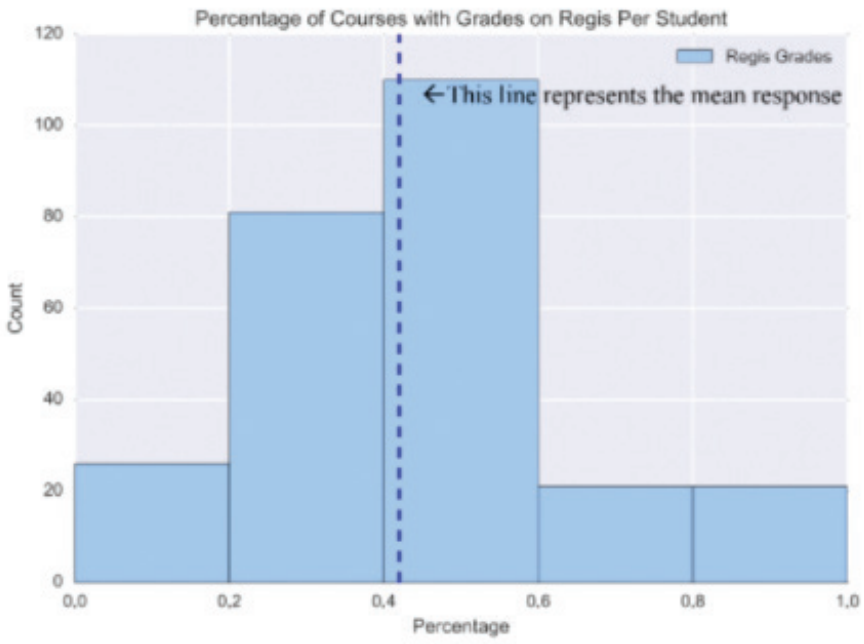


Figure 1: Distribution of the fraction of classes a student is enrolled in that distribute midterm progress grades.

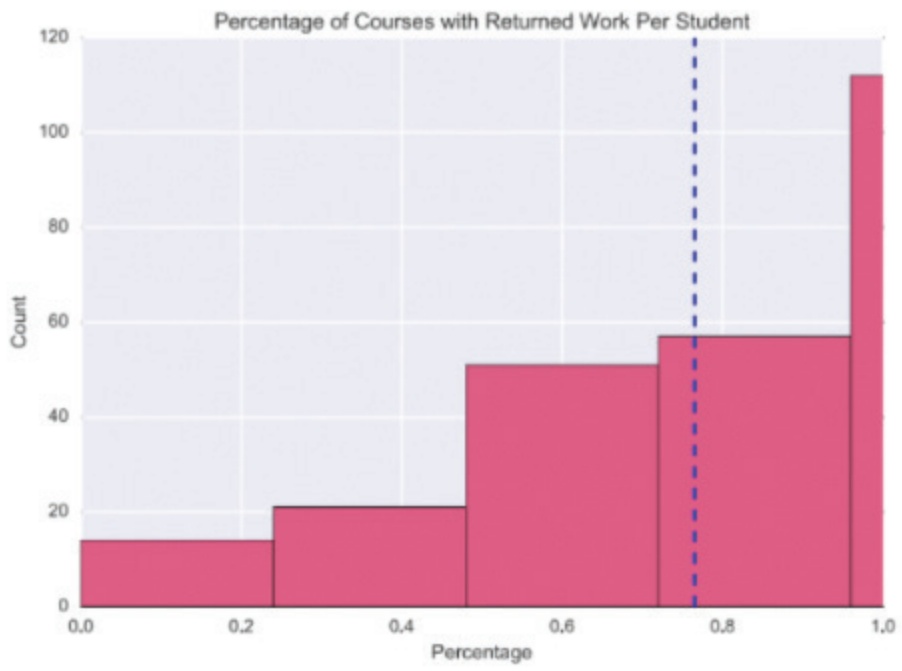


Figure 2: Distribution of the fraction of classes a student is enrolled in that returned all work through week 6 by week 9 of Fall term 2016.

Figures Courtesy of Timothy Liu

VICE PROVOST'S OFFICE HOURS

Vice Provost, Chief Diversity Officer, and Professor of English Cindy Weinstein holds regular office hours as an opportunity for undergraduate students, graduate students, and postdocs to meet for discussions pertaining to the Council on Undergraduate Education; Caltech accreditation; the Staff and Faculty Consultation Center; Student-Faculty Programs; the Center for Teaching, Learning and Outreach; the Caltech Diversity Center; and the Caltech Libraries.

There are four 15-minute appointments available per office hour. Sign up in the Office of the Vice Provost, Parsons-Gates room 104, ext. 6339 or by sending an email to dlewis@caltech.edu. We look forward to hearing from you!

Student Office Hours for Spring Term 2017:

4/27/17 Thursday 9:00-10:00 a.m.
5/2/17 Tuesday 11:00 a.m.-12:00 p.m.
5/9/17 Tuesday 11:00 a.m.-12:00 p.m.
5/17/17 Wednesday 11:00 a.m.-12:00 p.m.
5/24/17 Wednesday 11:00 a.m.-12:00 p.m.
5/31/17 Wednesday 11:00 a.m.-12:00 p.m.
6/8/17 Thursday 11:00 a.m.-12:00 p.m.

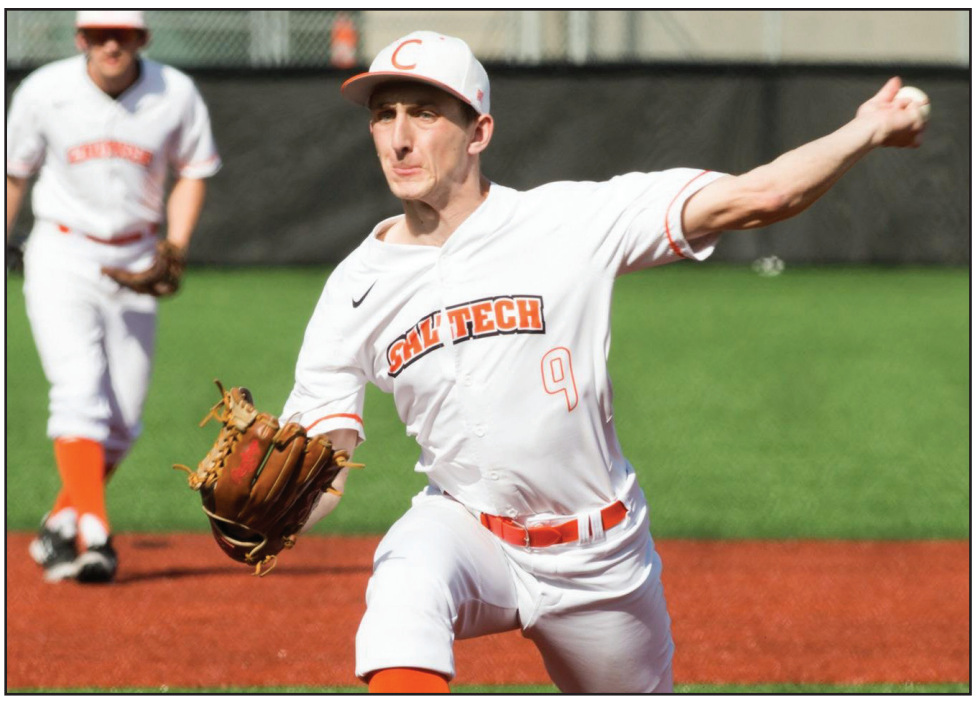
Krop tosses gem against Saint Katherine

GOCALTECH.COM
Actual Sports Content Editor

PASADENA (Apr. 28, 2017) – Caltech baseball needed a standout performance from starting pitcher Jonah Krop and that's exactly what they got when the Beavers hosted Saint Katherines College in the first of a three-game weekend series on Friday afternoon.

Behind the strong-armed Krop, the Beavers defeated the Firebirds, 3-1, for their eighth victory of the season. Krop fired five scoreless innings to start the game and manuevered around the adversity he faced in the sixth inning and beyond, almost emotionless on the mound. He certainly had his stuff working, as the Firebirds could only muster three hits on the sophomore. Krop also limited the walks, allowing just three free passes over nine innings while striking out five. After taking his lumps as a freshman, Krop took a big step forward in 2017 as the Beavers' top pitching option. He turned in a similar performance in the Beavers' historic victory over Pomona-Pitzer Colleges back on Mar. 31.

Caltech staked its pitcher to an early lead in the second inning when the returning Chris McCarren knocked in junior Garrett Levine on a shot through the right side. Not to be outdone by Krop's big game, McCarren took responsibility for all three of the Beavers' runs and put his team ahead in the eighth inning. With the bases loaded. McCarren floated a single over the head of the Firebirds' shortstop to score senior Kai Kirk and sophomore Mark Burleson, both of whom provided Caltech with a spark at the top of the order. McCarren had been battling a hand injury for the better part of the last month but received clearance to slot in as the designated hitter for the Beavers' final



"I am the Senate." -Jonah Krop, probably

-gocaltech.com

Women's water polo closes out season in SCIAC Tournament

LA VERNE, Calif. (Apr. 21, 2017) – Caltech women's water polo finished up its season in the SCIAC Championships hosted by the University of La Verne over the weekend, first against Occidental College on Friday before taking on the University of Redlands on Saturday. Sophomore Brittany Percin finished her season on a seven-game scoring streak and with 55 total goals over 18 games, topping her freshman total (51) while finishing one goal off of Ashley Grant '07's program record.

Friday: Caltech 4, Occidental 18

Percin extended her scoring streak to six games in the first of her team's two weekend games. Occidental attacked quickly and led by four by the time Percin took advantage of an exclusion. The Beavers exhibited some of their best defensive moments of the game in the second quarter when they held the Tigers to just four goals. The period also saw sophomore Hana Keller assist senior Mary Boyajian for her only goal of the game. The next goal for the Beavers did not fall until halfway through the third quarter when sophomore Katie Johnston scored. The Beavers defense only gave up two goals in the third period before Percin added to her scoring total on a pass from junior Devi Ganapathi. Freshman goalie Sarah Kreider made three saves for the Beavers.

Saturday: Caltech 4, Redlands 14

The second day of the tournament went slightly better for the Beavers against Redlands. The first minutes of the game were close as Johnston knotted the game at one with five minutes remaining in the first quarter. Seconds later, the Bulldogs fired off four more goals to put the Beavers at a five-goal deficit to end the period. Percin scored twice more and freshman Mackenzie Wooten scored her second goal of the season on a pass from Percin, whose final goal came on a buzzer-beater in the final frame. The Beavers' defense tightened late, holding the Bulldogs to just four goals in the second half.

Head Coach Jon Bonafede's Beavers finish their season 1-17 overall and received positive contributions up and down their young squad. They will look to build upon their 2017 next spring when they'll look for the first SCIAC win in program history.

10/10 would swipe right on that face.

-gocaltech.com

Baseball wraps season, honors seniors in Saint Katherine Doubleheader

GOCALTECH.COM
Actual Sports Content Editor

PASADENA (Apr. 29, 2017) – Caltech Baseball brought a successful 2017 season to an end on Saturday with an afternoon doubleheader against St. Katherine College. While the Beavers could not quite recreate the success from Friday's opening game in the series, one Beaver is now in sole possession of a key single-season record.

Sophomore Mark Burleson wrapped 2017 as Caltech's record holder for hits in a single season, breaking the joint record formerly held by Brian Panserini '12 and Greg Fricke '00 with 46 hits over 38 games. Not to be outdone, fellow sophomore Connor Moffatt had a career year in his own right. Moffatt's 40 hits tied the previous record held by Panserini and Fricke and his 10 doubles tied a single-season record occupied by four former Beavers and one of his teammates--Burleson, who doubled 10 times in his freshman season. Both players should be building blocks for Head Coach Matthew Mark to construct his roster around for the next two seasons.

Game 1: Caltech 1, St. Katherine 2

The first game featured senior Kai Kirk on the mound to make the final start of his two-year Caltech career. Kirk did not disappoint the Caltech faithful, pitching all seven innings while surrendering just two runs on five hits while striking out three firebirds over that span. Both of the runs came in the first and second innings, meaning Kirk's final five innings in a Caltech uniform featured shutout were shutout innings. His consistency on the mound kept the Beavers in the game and his teammates managed to deliver in spots. The Beavers' lone run came across when senior Tim Menninger, pinch hitting for Connor Moffatt knocked in freshman Cortland Perry on a single into left field in the sixth inning.

Seniors with their seniors.

-gocaltech.com

Game 2: Caltech 0, St. Katherine 9

The Firebirds found their power stroke in the third game of the weekend series and made it tough on a Caltech team looking to end its regular season on a high note. The Beavers' best moment came in the fifth inning when Tim Menninger tripled into right center on a lined shot that hopped between the right fielder and center fielder in the gap. Menninger, eager to deliver in his final game with the Beavers, jetted around the bases and beat the throw into third. Junior Chris McCarren had the Beavers' only other extra-base hit of the game when he doubled in the second inning. McCarren, who led the team with a robust .368 batting average, also went a perfect 11-for-11 in steal attempts. Speaking of steals, the seniors, looking to make one final impression in the orange and white were also active on the basepaths. Senior Kai Kirk, who started in left field swiped two bags while fellow senior Harrison Jacobs stole second in the first inning.

Seniors Kai Kirk, Tim Menninger, Harrison Jacobs, John Galden, Schaeffer Reed, J.D. Feist and Matthew Edwards were honored for their contributions to the program in a pre-game ceremony.

The season has to be considering a resounding success for Mark and the Beavers, as they picked up two SCIAC victories including their first in 29 years while winning eight total games, a program-best under Mark's leadership. Receiving contributions up and down the lineup in addition to sound starting pitching, the Beavers will look to build upon this season's success in 2018.

Join the Meditation Mob!

Tuesdays, 12:00 - 12:50

Want to learn more about mindfulness meditation? It's a great way to improve your attention and to become more grounded in the present moment.

There's no religious component. We use secular, evidence-based meditation techniques.

We meet in the small room just off the lounge in Winnett. All students are welcome, from total beginners to more experienced meditators.

Mailing list and MP3 archive:
counseling.caltech.edu/students/meditation

CATALYST

A 3-workshop series offered twice this term. Pre-screening is required - call the counseling center's front desk at (626) 395-8331 for more information.

- Learn how stress affects you, and make a personalized stress response profile.
- Learn tools for being with stressful and difficult emotional experiences when you can't easily change them.
- Get a clearer sense of your moment-to-moment experiences.
- Learn how to separate from unhelpful patterns of thinking.
- Get a clearer sense of what's important to you, and how you can make choices in line with that.

Section 1: Wednesdays 4:00 - 5:00, April 19, April 26, and May 3rd

Section 2: Mondays 4:00 - 5:00, May 8, May 15, and May 22nd

Location: 229 Sherman Fairchild Library

ASCIT Minutes

Meetings are every week in SAC 13

ASCIT Board of Directors Meeting
Minutes for 28 April 2017. Taken by Alice Zhai.
Officers Present: Andrew Montequin, Tim Liu, Sakthi Vetrivel, Kalyn Chang, Alice Zhai
Guests: Sara Adams, Sarah Crucilla, Vincent Park
Call to Order: 12:18pm

President's Report (Andrew):
- Meeting with Rachael and Joe Shepherd about Bechtel town hall meeting Monday, May 1

Officer's Reports:
V.P. of Academic Affairs (ARC Chair: Tim):
- ASCIT teaching award nominations will be up until next week
- Writing a survey about academic advising and how students use it to see whether people find it helpful
- Met with math department about rearranging the curriculum
- Course capture is happening - people will start recording lectures
- Appointing student reps on student faculty board committees

V.P. of Non-Academic Affairs (IHC Chair: Rachael):
- Absent

Director of Operations (Sakthi):
- Got proofs for '15-'16 yearbooks - actual copies will be distributed soon
- Looking into getting an ASCIT laptop

Treasurer (Kalyn):
- Multihouse funding pairs for this term are Fleming/Lloyd, Page/Avery, Blacker/Ricketts, and Dabney/Ruddock - none of the funds have been used yet
- Filing ASCIT's tax return
- Vincent Park pitched for funding for Chester wine tasting

Social Director (Robin):
- ASCIT Movie Night is on Friday, May 3

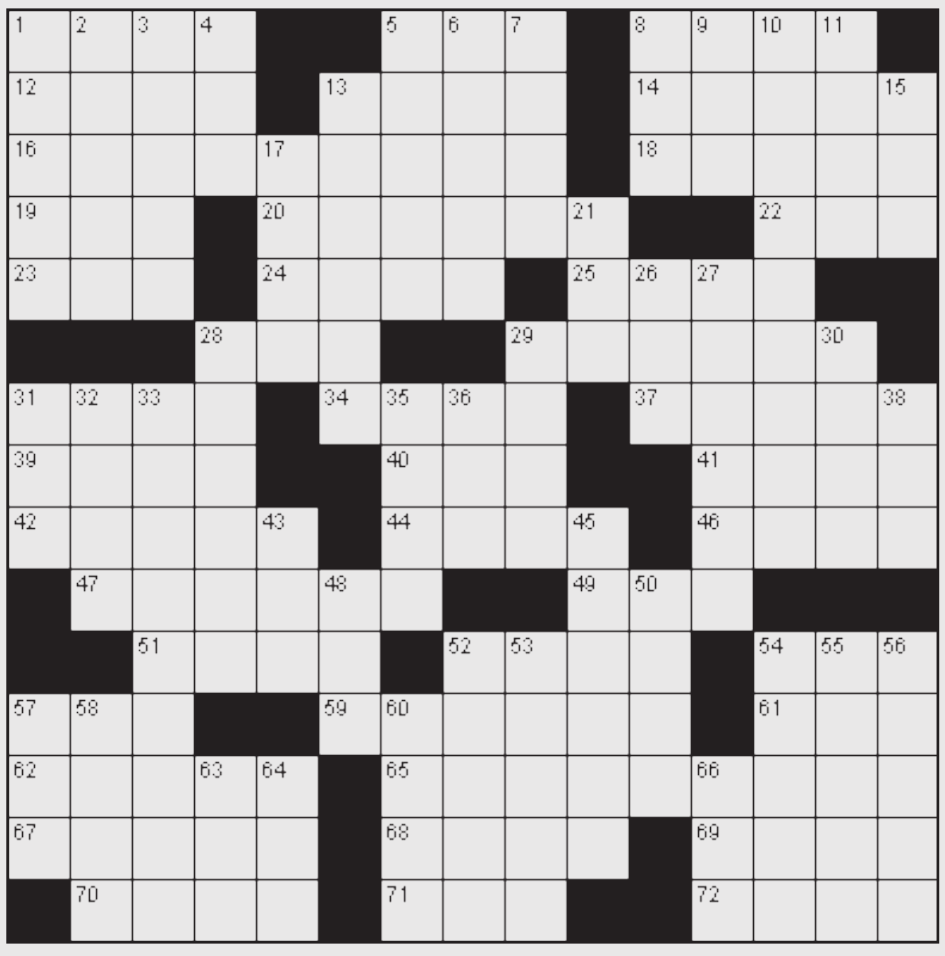
Secretary (Alice):
- Nothing to report

If anyone has any questions or concerns about a section of the minutes please email the appropriate officer. We are happy to answer any questions.
Meeting Adjourned: 12:49pm

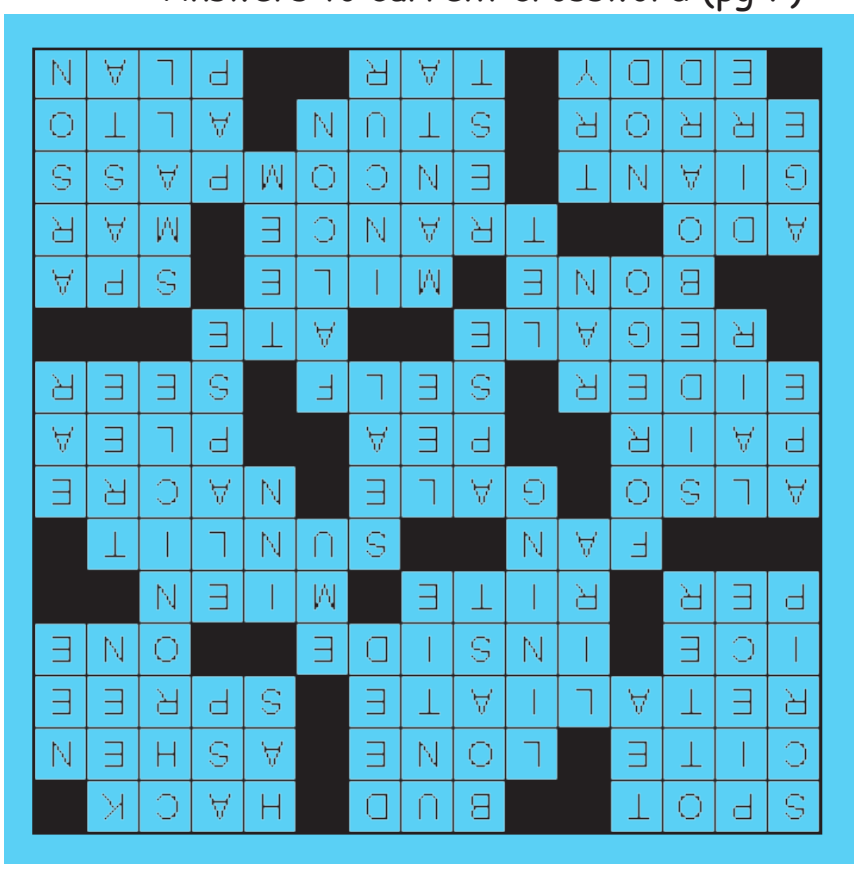
Crossword

Across
1. Catch sight of
5. Partially opened flower
8. Cut away
12. Make reference to
13. Solitary
14. Livid
16. Strike back
18. Fling
19. Frozen water
20. Interior
22. Single
23. For each
24. Customary observance or practice
25. Bearing
28. Ardent follower and admirer
29. Illuminated with natural light
31. In addition
34. Strong wind
37. Mother-of-pearl
39. Couple
40. Small vegetable
41. Supplication
42. Type of duck
44. Ego
46. Oracle
47. Provide with plenty of food or drink
49. Consumed
51. Osseous tissue
52. Unit of length
54. Health spring
57. Fuss
59. Psychological state
61. Spoil
62. Behemoth
65. Include in scope
67. Mistake
68. Stupefy
69. Singing voice
70. Miniature whirlpool
71. Pitch
72. Scale drawing

Down
1. Security certificate
2. Fragment
3. Musteline mammal
4. Beverage
5. Brag
6. Undo
7. Notable achievement
8. Possesses
9. Small snake
10. Historical record
11. Acute
13. Protective covering
15. Indicating maiden name
17. Former currency of Italy
21. Large flightless bird
26. Tavern
27. Pass by
28. Be earlier in time
29. Impression used to authenticate a document
30. Large woody plant
31. Caricature
32. Den
33. Piece of furniture
35. Part of a church
36. The sheltered side
38. Sense organ
43. Operated
45. Bird of prey
48. Allow
50. Swarm
52. Large tropical ray
53. Become liable to
54. Limited in size or scope
55. Shaped and dried dough
56. Incendiarism
57. Historic period
58. Desperate
60. Remainder
63. Gesture
64. Attempt
66. Spoon food



Answers to current crossword (pg 7)



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