

Engineers Model the California Reservoir Network

ROBERT PERKINS

Caltech Strategic Communications

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

Study offers reservoir managers insight on how to plan and respond to drought conditions

For the first time, engineers at Caltech have developed an empirical statewide model of the California reservoir network. The model was built from data gathered over a 13-year period that includes the latest drought, allowing researchers to make observations about how 55 of the state's major reservoirs respond to a variety of external conditions as a unified system.

Reservoirs act as the state's buffer against climate variability, stockpiling water during the rainy season for use during the dry. The water may be released to generate hydroelectric power, and can be diverted to agriculture and residential consumption. Meanwhile, a reservoir itself is often used for recreational purposes, such as swimming and boating. The reservoirs are interconnected in that they are placed along major waterways, with some downstream of others, and also because they can receive similar amounts of water

input and can be subject to similar management decisions.

The managers of these facilities must maintain a baseline amount of water in each reservoir. As the water level drops closer to that minimum mark, they dial back the amount of water released, which in turn affects all of the reservoirs downstream. Reservoir managers try to avoid having to shut off the water release completely, since that can have catastrophic consequences for farms and communities that rely on the water. The behavior of a reservoir—the rising and falling of the water level—is determined in part by shifts in the climate and in part by the humans managing the outflow of the reservoir. These two components can make reservoir storage challenging to predict.

“The bread and butter of hydrology is using physical laws to describe water phenomena. But the behavior of these reservoirs is not solely determined by physical laws of the water cycle, but also by demands and what these reservoirs are being used for,” says Caltech graduate student Armeen Taeb, lead author of a paper about the model that was published on November 22 by the journal *Water Resources Research*. “The significant human component in the behavior of reservoirs means that physics-

based modeling quickly becomes intractable in settings with large number of reservoirs.”

To solve this issue, Taeb and his colleagues—Venkat Chandrasekaran, professor of computing and mathematical sciences and electrical engineering at Caltech, and John Reager and Michael Turmon of JPL—used statistical techniques to learn from the past to shed light on how reservoirs will respond to different climate patterns in the future. They compared fluctuations in reservoir water levels between 2003 and 2016 to a variety of factors, such as precipitation, the severity of the drought, the snowpack levels in the Sierras, and levels of other California reservoirs. The researchers found that the biggest predictor of changes in the reservoir network was the Palmer Drought Severity Index, which was developed by the National Weather Service in 1965.

With this empirical model, Taeb says, managers can get a clearer picture of the demands that will be placed on their reservoirs, and can adjust their behavior earlier by curtailing water releases more gradually—reducing the possibility of having to cut off water releases altogether.

“Let's say you're in a drought and you have an advanced prediction of the drought index value in two months,” Taeb says. “You can look at our plot and ask, ‘Okay, what is the likelihood of reservoir exhaustion if we just stick to business as usual?’ And if you see that it's high, you need to get out of your routine and do something now before you get in trouble.”

As an analogy, think of a driver's response to a red light. If the driver sees the red light with a lot of time to react, he can slowly ease on the brakes—which is safer for all of the drivers behind him. If, instead, he waits until the last minute and slams the brake pedal to the floor, he is more likely to cause an accident for everyone behind him.

The 2012-2015 drought, which inspired Taeb and his colleagues to pursue this research, was among the most intense to occur in the past 1,200 years. “We were really close to disaster by the end of the drought period. In fact, two of the 55 reservoirs studied in our work had zero or very little water release in 2014,” Taeb says. In the future, the state will periodically experience droughts while demand for water is ever increasing amid a growing population, and so the strain placed on the California reservoir network is likely to occur

again, says Taeb—who believes that guidelines are needed to ensure the state does not face a system-wide catastrophe.

“Because of the frequent shortages of surface water, California has to resort to pumping out water from the ground, but that's not sustainable because there isn't enough rain to replenish the amount we're taking out. It won't last,” he says. Taeb and his co-authors believe that their model is an important data-analysis tool that should be used as input in the decision-making process when enforcing effective, sustainable water-management policies.

Taeb says that the same sort of empirical modeling could also be used in other states facing similar challenges.

His study is titled “A Statistical Graphical Model of the California Reservoir System.” The research was supported by the National Science Foundation, the Air Force Office of Scientific Research, the Alfred P. Sloan Foundation, the Resnick Sustainability Institute at Caltech, and JPL's Data Science Initiative.

The Strange Case of the Scuba Diving Fly

LORI DAJOSE

Caltech Strategic Communications

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

The flies of Mono Lake have puzzled observers—including author Mark Twain—for over a century with their ability to crawl underwater without getting wet. New research from Caltech makes progress in solving this scientific mystery.

More than a century ago, American writer Mark Twain observed a curious phenomenon at Mono Lake, just to the east of Yosemite National Park: enormous numbers of small flies would crawl underwater to forage and lay eggs, but each time they resurfaced, they would appear completely dry.

In his travel memoir *Roughing It*, Twain wrote: “You can hold them under water as long as you please—they do not mind it—they are only proud of it. When you let them go, they pop up to the surface as dry as a patent office report,

and walk off as unconcerned as if they had been educated especially with a view to affording instructive entertainment to man in that particular way.”

Caltech biologist Michael Dickinson, Esther M. and Abe M. Zarem Professor of Bioengineering and Aeronautics, became similarly intrigued by these so-called diving flies—scientifically known as *Ephedra hians*—on a vacation to Yosemite 22 years ago. Now the principal investigator of a laboratory that specializes in insect flight, Dickinson teamed up with former Caltech postdoctoral scholar Floris van Breugel (now at University of Washington) to study the mysterious behavior of the Mono Lake flies.

The two have now characterized the unique adaptations of the Mono Lake fly and the mechanisms it utilizes to crawl underwater without getting wet. The work is published in a paper in the November 20 issue of *Proceedings of the National Academy of Sciences*.

“Mono Lake has a very delicate and unique ecosystem,” says van Breugel. “Conservationists have fought hard to prevent its loss. We were interested in the Mono Lake flies not only because their behavior is so unusual, but because they are a crucial species for the lake's ecosystem and food web. Mono Lake flies are a crucial component to the local ecosystem, acting as a food source for spiders and for migratory and nesting birds.”

Mono Lake is not an average freshwater lake. Not only is it three times saltier than the ocean, it's also full of sodium carbonate and borax—which is essentially laundry detergent. The water's high pH gives it a slippery, almost oily texture.

No fish or other vertebrates survive in Mono Lake, though algae and bacteria are abundant. Thus, for a fly, the depths of the lake may seem appealing—there are no predators and plenty of food. However, there's just one hurdle

to overcome first: how to stay dry while underwater.

To something the size of a tiny fly, water's surface tension is powerful, making it a deadly sticky trap. All insects need to be water repellant, or hydrophobic, in order to coexist with rain and dew in their environments. Most are able to accomplish this by sporting a coating of short bristly hairs covered in a waxy substance, which allows them to repel water for the most part.

However, due to its peculiar chemical make-up, Mono Lake water is particularly good at breaking through an average insect's hairy defenses. Van Breugel and Dickinson discovered that this is because the surface of the lake contains a thin layer of negatively charged carbonate ions. When a regular fly gets too close to the water, the ions are attracted to positive charges on the fly's skin and the water is pulled between the protective hairs, wetting the fly.

So, how can the Mono Lake fly dive and stay dry in what Dickinson calls “perhaps the wettest water in the world”?

Using a combination of high-speed video and micro-force measurements in which they plunged flies into a variety of different chemical solutions, van Breugel and Dickinson found that the Mono Lake fly creates a protective bubble of air around its body when crawling into the lakewater. This bubble is a result of an extreme water-repelling phenomenon called superhydrophobicity. The flies are able to do this, the researchers discovered, because they are hairier than the average fly and coat their bodies and hairs with waxes that are particularly effective at repelling the carbonate-rich water. They also have large claws on their feet, which allow them to crawl on underwater rocks while resisting the naturally buoyant force of the bubble. Remarkably,

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Caltech Y Column

CALTECH Y

The Caltech Y Column serves to inform students of upcoming events and volunteer opportunities. The list is compiled by Katherine Guo from information given by the Caltech Y and its student leaders.

Founded by students in 1916, the Y was organized to provide extracurricular activities planned and implemented by students as an opportunity to learn leadership skills and discover themselves. The mission of today's Y remains the same—to provide opportunities that will prepare students to become engaged, responsible citizens of the world. The Y seeks to broaden students' worldviews, raise social, ethical, and cultural awareness through teamwork, community engagement, activism, and leadership. More information about the Caltech Y and its programs can be found at <https://caltechy.org>. The office is located at 505 S. Wilson Avenue.

Upcoming Events

Costa Rica Alternative Spring Break Trip

Saturday, March 17th through Sunday, March 25th (9 days) | Cost: \$950

Applications Due: by Noon on November, 22nd

The Caltech Y is excited to seek applicants for our 2017 Alternative Spring Break trip to Costa Rica. Join other Caltech students for a conservation focused spring break trip this year. On the Costa Rica trip we will be working with a host organization OSA Conservation www.osaconservation.org – which is dedicated to protecting the globally significant biodiversity of Costa Rica's Osa Peninsula. Don't miss out on this fantastic opportunity to explore another part of our planet and make a tangible difference in the world.

Trips fees include transportation, lodging, and most food. The Costa Rica Alternative Spring Break trip is coordinated by the Caltech Y and has been made possible thanks to generous funding from the Frank and Elsie Stefanko Fund, the George Housner Fund, Caltech Student Affairs, and the Caltech Y. Spaces are limited.

Visit http://caltechy.org/programs_services/areas/asb/ for applications and more information.

The Caltech Y Social Activism Speaker Series presents:

Solving Climate Change: From Policy to Personal

Thursday | November 30th | 4:00 to 6:00 PM | Location: TBD

The Caltech Y Social Activism Speaker Series is hosting a panel with members of the Citizens' Climate Lobby, a non-partisan volunteer organization dedicated to national policy to address climate change.

Climate change is one of the most pressing issues facing humanity. While the impacts of emissions up to now will be felt potentially for decades, significant policy changes are required in the immediate future to address greenhouse gas emissions and reverse the warming

trend in the long term. Passing legislation to deal with this pressing issue however, remains a problem. CCL campaigns for the passage of a Carbon Fee and Dividend bill designed to tax carbon emissions and return carbon dioxide to its pre-1990s levels. This discussion will feature a panel of CCL members from a variety of backgrounds each of whom will bring their perspective to this issue. Each panel member will talk about their views and then take questions from the audience.

Presentations are intended to introduce one perspective in order to stimulate thought and to provide a forum for respectful dialogue and examination. The views expressed by speakers are solely those of the speakers. Presentations do not necessarily reflect the opinion of the California Institute of Technology or the Caltech Y and should not be taken as an endorsement of the ideas, speakers or groups.

Decompression 2.0

Friday | December 1st | 3:00 to 5:00 PM | Center for Student Services

We made the move... Decompression is now an end of the week stress reliever with activities, snacks and entertainment. Don't go into finals week stressed out. Join us at the end of class week for a little break before studying. A variety of drinks and snacks, entertainment and activities will be provided.

Caltech Y Explore LA Series The Broad Museum

Sunday | December 3rd | 2:30 PM | Cost: \$5 | Transportation Included

Sign-up starting Thursday, 11/16 at the Caltech Y

Join us on a visit to The Broad with the Caltech Y! The Broad is a contemporary art museum founded by philanthropists Eli and Edythe Broad. Designed by Diller Scofidio + Renfro in collaboration with Gensler, the museum is home to 2,000 works of art from the Broad collection, which is among the most prominent holdings of postwar and contemporary art worldwide, and presents an active program of rotating temporary exhibitions and innovative audience engagement. The 120,000-square-foot building features two floors of gallery space and is the headquarters of The Broad Art Foundation's worldwide lending library, which has actively loaned collection works to museums around the world since 1984. With in-depth representations of influential contemporary artists like Jean-Michel Basquiat, Barbara Kruger, Cy Twombly, Ed Ruscha, Kara Walker, Christopher Wool, Jeff Koons, Joseph Beuys, Jasper Johns, Cindy Sherman, Robert Rauschenberg, and more, plus an ever-growing representation of younger artists, The Broad enriches, provokes, inspires, and fosters appreciation of art of our time. This offer is for students only; however, students purchasing tickets are permitted to purchase tickets for up to one guest each – and that guest can be a non-student. Explore LA is coordinated by the Caltech Y. The Caltech Y is located in the Tyson House 505 South Wilson (Bldg. 128).

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Pasadena LEARNS

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

Come volunteer at Washington Middle and Elementary STEAM 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.

Hathaway Sycamores

Every Monday | 5:45 - 8:00 PM | Highland Park

Volunteer at Hathaway Sycamores, a group that supports local underprivileged but motivated high school students. There are a variety of ages and subjects being tutored. The service trip includes about 40 minutes of travel time and 1.5 hours of tutoring. Transportation is included.

For more info and to RSVP email Elisabeth at egallmei@caltech.edu. Eligible for Federal Work Study.

Mentors for L.I.F.E

Volunteer times: 2:45 - 5:00 PM at various locations in Pasadena

Stressed out by school? Step outside the Caltech bubble and mentor tweens who've yet to even consider 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.

Back to the Nineties: Returning Hong Kong to China

TIMOTHY LIU
Contributing Writer

The builders of Hong Kong's new international airport were in a bind. The massive infrastructure project included digging two tunnels, erecting three bridges, laying a new railway line, and flattening two islands to make room for the airport. Originally slated to be opened in 1997, the project was running behind schedule, hobbled by a demanding timeline and struggles with securing financing. To make the situation even more complicated, the land the airport was being built on was about to be transferred to another sovereign government.

In 1841, the British seized Hong Kong from the Chinese government in a burst of imperialist aggression. British gains were solidified more than fifty years later under the Convention for the Extension of Hong Kong Territory. The agreement, which was signed by the crumbling Qing Dynasty, leased the land surrounding Hong Kong to the British empire for 99 years. Over the next century, the city grew into one of the busiest ports in the world and an international financial hub. Under the aegis of British Crown rule, Hong Kong enjoyed relative stability and fast economic growth while the mainland was

wracked by periods of instability.

Claude MacDonald, the British representative during the 1898 negotiations that leased Hong Kong to Britain, remarked that a 99 year lease was "as good as forever." However, by the 1980s the question of the handover began to grow in urgency. In 1982, British Prime Minister Margaret Thatcher signed the Sino-British Joint Declaration, initiating the byzantine process of transferring Hong Kong to the People's Republic of China. The agreement also gave birth to the principle of "one country two systems," a sometimes self-contradictory concept that posits the existence of a single Chinese state but with some regions granted special autonomy.

The next step in the transfer took place on April 4th 1990 when the Hong Kong Basic Law was ratified and approved by the communist Chinese government. The Basic Law is effectively a constitution for Hong Kong, and outlines the relation between the mainland government centered in Beijing and the semi-autonomous local Hong Kong government. The document gave residents of Hong Kong relatively more freedom than that enjoyed by citizens of mainland China. It also stipulated that the economic system of Hong Kong would remain unchanged.

One of the General Principles of the law declared that: "The socialist system and policies shall not be practised in the Hong Kong Special Administrative Region, and the previous capitalist system and way of life shall remain unchanged."

July 1st, 1997 - the day of the transfer - came with fireworks and fanfare. A crowd of onlookers, unfazed by steady rain, watched as the Union Jack was lowered one last time from Governor Chris Patten's residence. The night was consumed by parties and celebration, momentarily sweeping aside the anxiety and uncertainty that came with the handoff of power. In the twenty years since, Hong Kong has preserved a unique degree of autonomy, enshrined by its own passport, currency, and local government.

But rather ominously, the promise of non interference guaranteed by the Hong Kong Basic Law came with a sunset clause. The protection on the "capitalist system" was only guaranteed for 50 years, expiring in 2047. After that, the Chinese government may choose to exert greater control or completely integrate Hong Kong into the rest of the China, stripping it of its autonomy. Beijing has remained tight-lipped on its plans for Hong Kong after that



Chris Patten, the last governor of Hong Kong, receives the folded British flag after it was lowered from his residence for the last time. July 1st, 1997.

Photo Courtesy of AFP

date, and what happens could once again throw Hong Kong into crisis.

"Back to the Nineties" is a semi-regular column about historical events. Pieces will focus on events from the 1990s and the turn of

the millennia and how they relate to the present day. If you have feedback or ideas please follow the link here goo.gl/zee2Ez or email me at tliu@caltech.edu.

Scuba Diving Flies

Continued from page 1

the bubble does not encase the fly's eyes, allowing the fly to see underwater without the bubble's distorting effect.

The team compared the performance of Mono Lake flies to a variety of different flies, including some close relatives. No other flies could take a dunk into Mono Lake water without getting wet to a degree that would make escape from the lake unlikely. Additionally, when the Mono Lake flies were briefly rinsed with a solvent (hexane) to dissolve their wax, they lost their ability to form a superhydrophobic bubble, suggesting that the fly's waxes are critical to this phenomenon.

"It's not that Mono Lake flies have evolved a new and unique way of remaining hydrophobic—it's that they've amplified the normal tools that most insects use," says Dickinson. "It's just a killer gig. There's nothing underwater to eat you and you have all the food you want. You've just got to dive in perhaps the most difficult water in which to stay dry on the planet. They figured it out, and so get to enjoy an extremely unique life history. It's amazing how the evolution of such small-scale physical and chemical changes can allow an animal to occupy an entirely new ecological niche."

The next steps for the project, according to Dickinson, are broad.

"We could go in the materials science direction and study the

chemistry of the waxes that the insects use," he says. "But there's also some really interesting neurobiology—it is such an incredibly weird thing for a fly to deliberately crawl underwater."

The paper is titled "Superhydrophobic diving flies (Ephydra hians) and the hypersaline waters of Mono Lake." Funding was provided by the National Geographic Society's Committee for Research and Exploration.



LEDs

The Microscopic Origin of Efficiency Droop in LEDs

ROBERT PERKINS
Caltech Strategic Communications

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

Semiconductor study shows that the coupling between electrons and thermal vibrations may be sapping energy from LEDs. Light-emitting diodes—or LEDs, as they are commonly known—have been slowly replacing incandescent light bulbs in applications ranging from car

taillightstoindicatorsonelectronics since their invention in the 1960s.

Eschewing the filament of an incandescent bulb and the mercury vapor of a fluorescent bulb, LEDs instead generate light by applying a voltage across a semiconductor. Electrons combine with holes (places in the crystalline structure where an electron could but does not exist, making them positively charged), leading to the emission of photons—particles of light.

Most LEDs use semiconductors made from a material called gallium nitride (GaN). These GaN LEDs are reliable and safe, but have the disadvantage of quickly becoming inefficient as the voltage is scaled up, a phenomenon called "efficiency droop."

"More than 10 percent of electricity generated in the U.S. is used for lighting in the commercial and residential sectors. A switch to the widespread use of LED lighting would lead to dramatic energy savings, but efficiency droop is a major roadblock," says Marco Bernardi, assistant professor of applied physics and materials science in the Division of Engineering and Applied Science at Caltech and corresponding author of a recent paper on the source of efficiency droop that was published in *Nano Letters*.

Efficiency droop occurs when excited electrons overshoot nanometer-deep quantum wells in GaN. The wells are designed to trap electrons into combining with holes. When electrons are too energetic to be trapped by the wells, they leak out of LED devices without emitting any light.

"Several models have been proposed to explain this electron

leakage, but they tend to focus on qualitative analyses that use intuition to justify experimental evidence," Bernardi says.

Using new computational methods developed at Caltech, a team led by Bernardi studied GaN at an atomic level and how lattice vibrations—the background "hum" of atomic thermal motions in a solid—affect electrons in the material. It was known that this hum drains energy from both electrons and holes. However, Bernardi found that the drain occurs faster for holes than electrons—a mismatch that allows the electrons to overshoot quantum wells, escaping the GaN without ever combining with holes and emitting light.

"Our work shows for the first time that the ever-present interaction between electrons with lattice vibrations can, by itself, explain why excited electrons can leak out of the active layer and account for inefficiencies in GaN LEDs," Bernardi says.

Bernardi and his colleagues have not yet finished investigating droop in GaN. Next, they plan to study how droop depends on temperature and other material properties.

The study is titled "Ultrafast Hot Carrier Dynamics in GaN and its Impact on the Efficiency Droop." The co-lead authors of the study are graduate student Vatsal A. Jhalani, who is supported by a graduate fellowship from the Resnick Sustainability Institute at Caltech, and Jin-Jian Zhou, postdoctoral researcher at the Joint Center for Artificial Photosynthesis at Caltech. This research was funded by the Resnick Institute, the Department of Energy, and the National Science Foundation.

Photo Courtesy of Caltech

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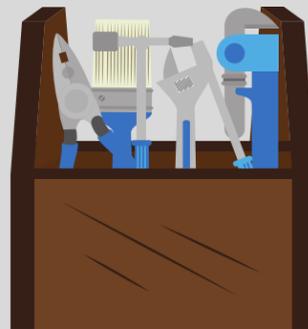
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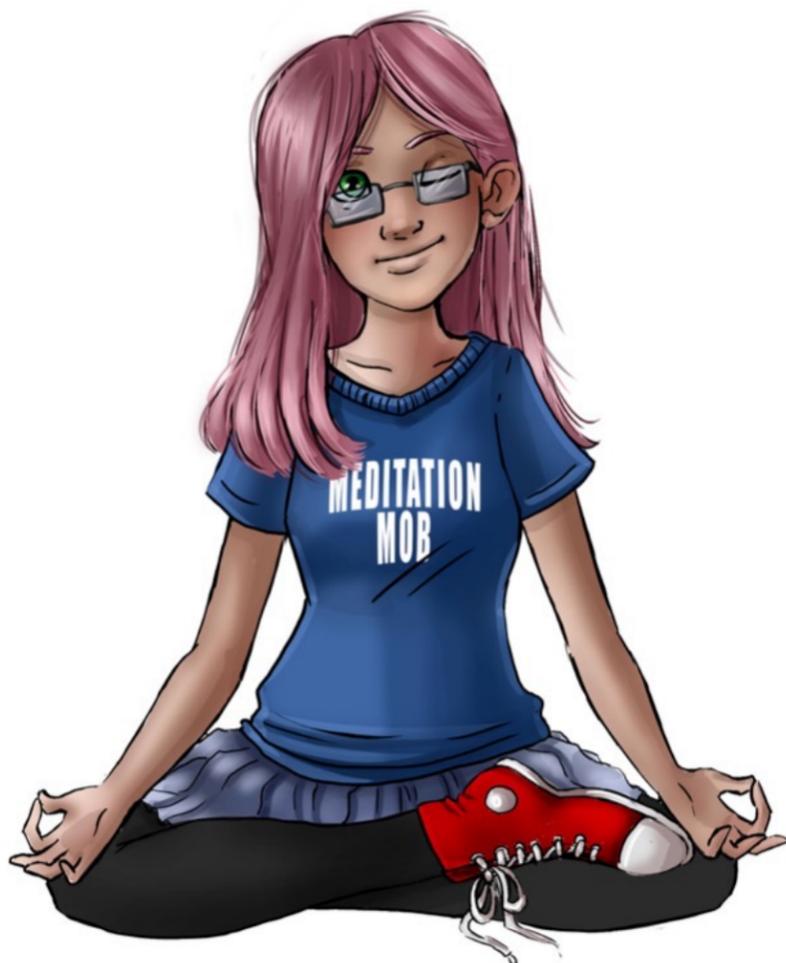
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D'Costa Gets Double-Double in 2OT Barnburner

GOCALTECH.COM
Actual Sports Content Editor

PASADENA (Nov. 25, 2017) – The second day of the Caltech-Occidental Fall Classic brought out the best in the

double from sophomore guard Samantha D'Costa (San Jose, Calif. / St. Francis).

D'Costa's double-double marked the first of the year for the women's team and while the game did go two extra periods,

figures in either of the Beavers' first two games but made clear early she was ready to put those games behind her, as she scored the Beavers' first six points including a fastbreak layup to open the game. D'Costa's fast start proved metaphorical for the rest

the first two quarters thanks in part to the Pioneers going 0-for-12 from three.

The Pioneers recovered quickly in the second half and answered with a six-point run of their own to bring the game within six. The visitors eventually earned their way back to a share of the lead, but 10 fourth quarter points from sophomore guard Grace Peng (San Ramon, Calif. / California) stymied the Pioneers and played a role in the Beavers coming back from a six-point deficit with seven minutes to play and eventually force a first extra period. The Beavers fell behind again in the first five-minute overtime period but recovered when junior Madeline Schemel (Westport, Conn. / Staples) tied the game once again with a short jumper from D'Costa with two seconds left that rattled around the rim before falling in. The Beavers met a similar fate in the second overtime frame but had multiple chances to win the game when Peng first fired a three-pointer with eight seconds to go and then stole the ball back as soon as the Pioneers began to transition back down the court. The sophomore finished the game with 19 points, eight rebounds, six assists and five steals and along with D'Costa, did so without taking a breather. Both players played the game's entirety, all 50 minutes worth. Junior guard Nika Haleftiras (San Diego, Calif. / Our Lady of Peace) also maintained a steady scoring presence for the Beavers, shooting 6-for-11 from the field for 13 points to go along with seven rebounds and five steals.

Head Coach Bridgette Reyes and the Beavers will have a week to get ready for Claremont-Mudd-Scripps Colleges in their SCIAC opener. The game is set for Dec. 2 at 5:00 p.m.



This is potentially the most focused face I've seen in a long time

-gocaltech.com

Caltech women's basketball team, which took visiting Lewis & Clark College to double-overtime on the heels off a double-

D'Costa managed to complete the feat within regulation. D'Costa has started the year slow with her shot and had yet to reach double-

of the team as well. The Beavers led the Pioneers 28-16 at halftime and held their opponents to just eight points in each of

Three Reach Double Figures Against Linfield

GOCALTECH.COM
Actual Sports Content Editor



"A hand? In my face? Disgusting" - Marcus, probably

Photo Courtesy of Noelle Davis

LA VERNE, Calif. (Nov. 22, 2017) – Caltech men's basketball freshmen Marcus Gee (Santa Monica / Santa Monica) and Spencer Schneider (Houston, Texas / Clearbrook), along with sophomore Alec Andrews (Folsom, Calif. / Folsom) hit double-figures as the Beavers tested Oregon-

based Linfield College at the University of La Verne on Thanksgiving Eve.

Gee and Schneider each tallied 11 points and Andrews led the Beavers for a second game in as many days, this time scoring 12

points. Gee scored all 11 of his points in the second half, which proved key in the Beavers' presence as a constant threat to the Wildcats, who entered the game coming off a victory over La Verne at Braun Gymnasium on Tuesday. The Beavers trailed the Wildcats by

eight at halftime and actually outscored their opponents in the second half, 29-28. Gee's shooting touch played a role as the freshman shot 50-percent from the field in the second half with two three-pointers.

Matching Linfield in the turnover battle proved to be another key for Caltech. Both teams finished the game with 14 assists to 15 turnovers, just under a 1:1 ratio. If the Beavers can maintain a sustainable pace around the 1:1 mark, it would be a likely improvement on last year's 3:4 assist-to-turnover ratio. Andrews, along with fellow guard Bret Johnson (Carlsbad, Calif. / Santa Fe Christian) played a role in the offensive side of the Beavers ratio. Both players came up with four assists while Johnson (chipped in with seven points of his own. Sophomore center Calvin Huh (Fort Lee, N.J. / Bergen Tech) also had another solid game beneath the glass, finishing the day with eight points and eight rebounds.

Head Coach Dr. Oliver Eslinger and the Beavers will spend the next week preparing for another round robin, the Lee Fulmer Memorial Classic hosted by the University of Redlands. The Beavers will take on the University of Wisconsin Whitewater on Friday before meeting the University of California Santa Cruz in the Saturday game. Both games are set for 5:00 p.m. start times.

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Here's your chance to nominate your favorite professor for the 2017-18 Richard P. Feynman Prize for Excellence in Teaching! You have from now until December 15, 2017 to submit your nomination package to the Provost's Office to honor a professor who demonstrates, in the broadest sense, unusual ability, creativity, and innovation in undergraduate and graduate classroom or laboratory teaching.

The Feynman Prize is made possible through the generosity of Ione and Robert E. Paradise, with additional contributions from an anonymous local couple. Nominations for the Feynman Teaching Prize are welcome from faculty, students, postdoctoral scholars, staff, and alumni.

All professorial faculty of the Institute are eligible. The prize consists of a cash award of \$3,500, matched by an equivalent raise in the annual salary of the awardee. A letter of nomination and detailed supporting material, including, but not limited to, a curriculum vitae, course syllabus or description, and supporting recommendation letters should be emailed to kkerbs@caltech.edu or directed to the Feynman Prize Selection Committee, Office of the Provost, Mail Code 206-31, at the California Institute of Technology, Pasadena, California, 91125. Nomination packages are due by December 15, 2017.

Additional information including guidelines for the prize and FAQ may be found at <http://provost.caltech.edu/FeynmanTeachingPrize>. Further information can also be obtained from Karen Kerbs (626-395-6039; kkerbs@caltech.edu) in the Provost's Office.



Totem Caltech's Literary and Visual Art Magazine

HA!KU AND PHOTO CONTEST

DEADLINE: JANUARY 5 • 11PM

This is a pair challenge! We'll still consider submissions from individuals, but we highly encourage you to find a friend to submit a haiku and photo together. Photos must be taken during the period between contest announcement and deadline.

Prizes: \$25 Amazon gift card per person for the winning haiku + photo submission.

Send submissions to totem@caltech.edu. For more info about Totem, please visit our FB page or totem.caltech.edu.



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Must qualify for CEFCU membership to join. Minimum \$5 deposit and one-time \$5 membership fee due upon opening any CEFCU account. Federally insured by NCUA.

ASCIT Minutes

Meetings are every week in SAC 13

No minutes for 11/24

ASCIT Board of Directors Meeting

Minutes for November 17, 2017. Taken by Alice Zhai.

Officers Present: Sakthi Vetrivel, Rachael Morton, Sara Adams, Sarah Crucilla, Alice Zhai

Guests: Robert Eng, Joshua Chen

Call to Order: 10:06 am

President's Report (Sakthi):

- Had VPSA meeting last Friday
- Midnight Donuts is next Tuesday
- Had budget meeting with Big T treasurer and Sarah Crucilla to discuss funding for Yearbook and increasing student dues
- Considering to assemble an ASCIT Financial Committee to look over our budget. Signups will be posted soon

Officer's Reports:

V.P. of Academic Affairs (Kavya):

- Drop day and registration happened yesterday.
- Git software Seminar went well on Thursday
- Arc retreat is this weekend
- Student Faculty Lunches are on 11/27 and 11/28, signups close 11/19 at 11:59pm

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

- Bechtel town hall meeting was last Tuesday. Attendance was about 70, including a decent amount of faculty.
- Notes from the meeting will be distributed.

Director of Operations (Sara):

- Page asked for ASCIT lights for their Interhouse.
- Many clubs have filed their club registration. Waiting for Club Steering Committee to vote on them

Treasurer (Sarah):

- Budget meeting went well
- Having difficulty working with administration on reporting expenses and filing reimbursements

Social Director (Alice):

- Signed contract for holding ASCIT Formal at City Club Los Angeles on Saturday, April 7th from 7-11PM.
- Alternate event for Page Interhouse is happening at Tom's house. Will be asking for volunteers to help set up.
- Planning an ice skating event at the Pasadena Ice Skating Center at the end of the term.

Secretary (Dana):

- Not in attendance.

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: 10:26 am

Crossword

Across

1. Travesty
6. Small snake
9. Nocturnal mammals
13. Fruit of the oak
14. Hawaiian garland
15. Reddish brown
16. Small inlet
17. Be in debt
18. Tripod
19. Liberate
21. Struggle between rivals
23. Gear
24. Turbulent water
25. Part of a circle
28. Part of the ear
30. Meal
35. Earthy deposit
37. Treaty
39. Fry briefly over a high heat
40. Notion
41. Air field
43. Heavy metallic element
44. Strainer
46. Champion
47. Rant
48. Sedate
50. Squad
52. Allow
53. Military installation
55. Taxi
57. A section of text
61. Sources of danger

65. Inflammatory lesion
66. Fish eggs
68. Ice hut
69. Austere
70. Compete for something
71. Relating to the nose
72. Sharpen
73. Hard tough wood
74. Positively charged electrode

Down

1. Impartial
2. Skin condition
3. Roster
4. Watercourse
5. Involve
6. Succulent plant
7. Darn
8. Fragment
9. Pulse
10. Part of a church
11. Binds
12. Sodium chloride
15. Mental faculties
20. Halts
22. Paddle
24. Conceal
25. Awry
26. Communication medium
27. Wicker fishing basket
29. Washtub
31. Couple
32. Relating to the ear
33. Cooking appliance

34. Religious doctrine
36. Wash or flow against
38. Become fatigued
42. Hunt illegally
45. Go onboard
49. Hen-peck
51. Docking facility
54. Tennis stroke
56. Started
57. Move with force
58. Singing voice
59. Read metrically
60. Withered
61. Swarm
62. In addition
63. Amphibian
64. Solitary
67. Lubricant

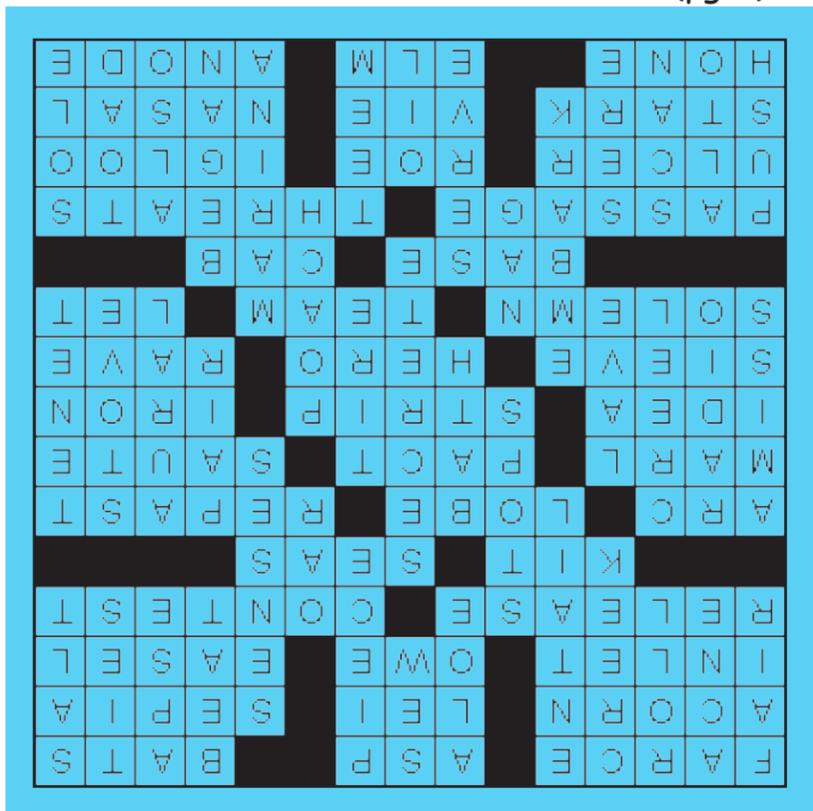
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72						73				74				

BOOM-SHAKA-LAKA

BY PAUL SENORREX

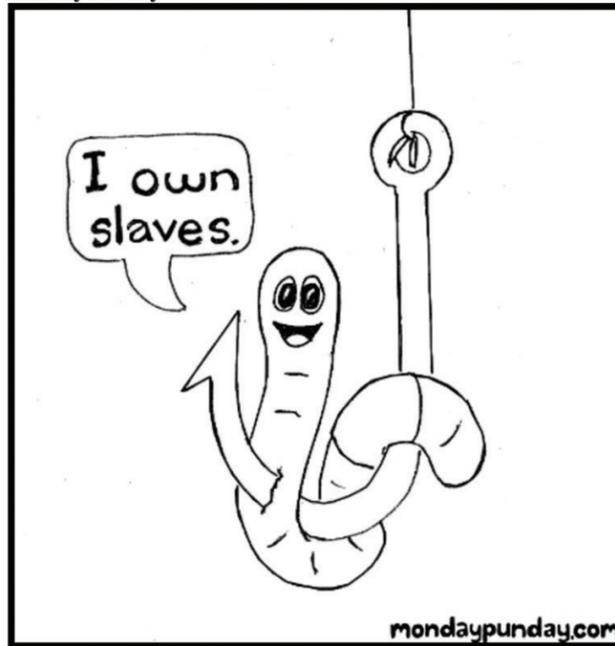


Answers to current crossword (pg 7)



-http://puzzlechoice.com

Monday Punday



This picture represents a common phrase, title, or person.

Think you know the answer? Take a guess at mondaypunday.com/258

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