Dear COSMOS Families and Friends,

It is hard to believe we’ve completed our third week of COSMOS and we are now headed in to our last week of final projects, speakers, outings and socials.

Last week’s Distinguished Lecture Series featured Jay Stachowicz, Professor of Evolution and Ecology here at UC Davis. He captivated us with his talk “Does biodiversity matter? A view from the California coast”

On Saturday we all headed out to the California State Fair. Despite the heat, everyone had a great time exploring all the fair has to offer.

This next week will be a busy one as students will be finishing up their class projects and looking forward to our Closing Social.

Now, for an update on Closing Day: Students will be given direction from their RAs about returning keys and cleaning their rooms. Please keep in mind that any student who does not return their key will be charged $50. Here is some important information for you:

**Saturday, August 5**

8:30-9:30 Parents/Guardians arrive at the residence hall to move their student out of dorm. **Students will not be able to return to the dorm following closing**, so please do not forget anything.

9:30-10:45 Parents/Guardians and students arrive at the Mondavi Center for project viewing and buffet breakfast. Please do not arrive at the Mondavi Center before 9:30 as there will be no admittance until then. Parking is free on Saturday.

10:45-11:45 Closing ceremony in the Mondavi Center. **Please limit to 2 guests per student for the ceremony.**

12:00 Airport shuttle will begin for students whose parents are not present and must depart from the Sacramento airport.

As always, if you have questions or concerns, you are welcome to contact us at any time:

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Below, you will find a report for each Cluster. This information is compiled from weekly reports submitted by the Teacher Fellows.
Monday marked the beginning of second half of our COSMOS adventure here in Davis. We were all caught by surprise when Michael, our TI, shredded his luscious ginger locks for a shorter haircut. In the morning, we toured the laboratories in the College of Engineering and examined the Scanning Tunneling Microscopes (STMs) used by graduate students for research. During our writing and communications class, Mr. Slizeski led us on a tour around the Earth Sciences building. We learned about various types of rocks from various different eras. You might be wondering why we were exploring geology in a writing class. We wondered too. For our afternoon class, Professor Scalettar gave us an invigorating lecture about the Schrodinger equation and basic matrices, going over how to exponentiate them and the derivation of the equations in our code all in under 60 minutes.

![Cluster 1](image)

Tuesday, we visited the National Center for Electron Microscopy and the Molecular Foundry, A seven-story tall, magnanimous piece of architecture. We were introduced to Dr. Alexander Weber-Bargioni, a staff scientist in the foundry. Alex led us through the foundry, showcasing the Foundry's greatest achievements. Alex explained the details of his lab's research about photosensitive semiconductors. After an incredible morning of cutting edge technology and fantastically interesting tour guides, we drove up to the neighboring Lawrence Hall of Science to eat our lunch and check out the exhibits. However, the best part about this palace of information was the awe inspiring view from atop the beautiful Berkeley Hills, looking over the magnificent bay like a mother bird watches her baby, nurturing yet ready to let it free into the world.

On Wednesday we finally began the treacherous journey to build our STM. This final project is the culmination of some of the most important quantum mechanics principles we have learned. At its core, the STM operates on the particle-wave duality of electrons, meaning that electrons have properties of both particles and waves. Four groups will each make an STM combining skills of electronics, programming, and mechanical. We also had our third distinguished lecturer, Jay Stachowicz, who spoke about the necessity of biodiversity. He launched into his presentation about the importance of biodiversity using decorating crabs and sea otters as examples to his point.
With Thursday came Dr. Scalettar guiding us as we worked on our programs that modelled the behavior of a quantum particle in a ring of atoms. We then started the code to model the particle hitting a potential barrier (a wall). In classical mechanics, this particle would bounce right back. Quantum mechanics is much stranger, and the quantum particle could *pass right through the barrier*, in a process called quantum tunneling. However, our code requires a lot of processing power, possibly having to run for hours. We had a cluster-one-exclusive special event on Thursday for lunch, a pizza party in front of the Physics Building. In the guest lecture, we were introduced to the evolution of the solar cell, by Professor Dong Yu, from the Department of Physics. Professor Yu briefly talked about facing issue of "dirty" energy. From there, he went into the discussion of solar energy, which is the biggest supplier of clean energy. He brought up solar cells’ properties, including band gap and efficiency.
Cluster 2

Cluster 2 had another mind-stretching week learning about atomic fission and critical conditions for nuclear chain reactions in the mornings with Dr. Grønbech-Jensen. In the afternoons, Dr. Yankelevich taught us more about lasers and electronics. In the optics lab, we finished assembling our photonic links, then examined some of their electronic properties by connecting them to a signal generator and an oscilloscope. First we measured the voltage amplitude of the output signal over a wide range of frequencies to determine the band width of our photonic links. Then we rearranged our instruments so we could measure the photonic link phase shift over a similarly wide range of input frequencies.
We took two fascinating field trips this week. On Tuesday, we travelled to Sacramento to see the nuclear research reactor at UC Davis’ McClellan Nuclear Research Center (MNRC). It is the highest power TRIGA™ (Training, Research, and Isotope Production General Atomics) reactor in the United States. Dr. Wesley Frey, director of MNRC, guided us on a tour of the reactor and adjacent radiography bays and told us how neutron radiography and neutron tomography are used to enhance investigations in the field of non-destructive testing. On Thursday, we toured the National Ignition Facility (NIF) located at Lawrence Livermore National Laboratory in Livermore. There we saw the world’s largest and most energetic laser. The giant laser has nearly 40,000 optics that precisely guide, reflect, amplify, and focus 192 laser beams onto a fusion target about the size of a pencil eraser. We were impressed with the immensity of NIF (the size of a sports stadium, with a NASA-like control room), and the high degree of security surrounding it.

On Wednesday, the COSMOS Distinguished Lecture was given by UC Davis professor Dr. Jay Stachowicz. Dr. Stachowicz’ lecture, entitled “Does Biodiversity Matter? The View from the California Coast” was very engaging. We learned three specific ways in which biodiversity can benefit ecosystems, with examples from California coastal kelp forests.

This week we also visited the UC Davis Physical Science Library, where many of us checked out books to help research our final projects. It was another amazing week at COSMOS.
Cluster 3 has been studying fuel cells and batteries, as well as design and optimization with Professor Park. The students have also been learning about mathematics, aerodynamics, thermodynamics and physics with Professor Hafez. They have also had problem solving labs and programming exercises with TA Aaron and teacher fellow Dr. Tavernetti. With Dr. Park students learned about vehicle power systems and also design of experiments and response prediction in empirical modeling of nonlinear behaviors in preparation for the catapult challenge next week, where teams will compete to predict outcome of a complicated experiment. With Professor Hafez they have been getting advanced lessons on the foundations and theory of aerodynamics. For field trips, the students visited the Engineering Student Startup Center (ESSC) at UC Davis, which is an on-campus space where UC Davis students can prototype ideas and collaborate on technology ventures. On Thursday the students first built their model rockets for next weeks launches, then visited the DMG MORI facility in Davis and learned about CNC Machine Tools and how they are made. The students also visited the engineering machine shop here on campus for a tour of the facility. The mathematics and classroom activities are definitely increasing in complexity and the students are overwhelming rising to that challenge and impressing all their instructors with their enthusiasm and remarkable capabilities. In addition to their classroom activities, the students made an impressive and standout performance of Titanic at the COSMOS wide talent show on Friday afternoon.
This week can be summarized in one word: tiring. We’ve had a great week, but we’ve been out very late two nights and are ready for a weekend to recover.

During class, students have been studying more about the origins of the universe, star formation and lifecycles (including supernovas), and planetary formation. They also have studied more about dark matter and its effect on the formation on early galaxies.

On Tuesday night, we took our longest fieldtrip to the Lick Observatory on Mount Hamilton. There, we took a tour of the Shane Telescope, a 3-meter Refractor which the University of California owns and manages on behalf of scientists around the world. We were able to go outside the dome for a catwalk tour right before sunset, where we were able to see a panoramic view from this highest peak of the Coastal Range. Mount Diablo was visible, but San Francisco and the Sierra Nevada range were hidden in the distance.

After a talk about the history of the observatory, we were able to view several stellar objects through the Great Lick Refractor, the telescope around which the observatory was originally built in 1888. Among these was a globular cluster similar to what our solar system may become in a few million years. At the end of the evening, students were treated to a sky tour from the docents. The dark skies around the observatory provide for excellent viewing and the docents had very interesting stories.

Since we didn’t get back to UCD until 3:30am, students had the morning off to rest, but projects took the afternoon and students are busy working hard. They also took time on Thursday night to observe from the roof of the UCD Physics building and to watch the UCD Astronomers who are using the Shane telescope—which we saw on Tuesday—observe some supernovae. This opportunity to observe real astronomy in action, using the instruments which we saw on Tuesday, is a tremendous treat for all of us.

Students were tired on Friday, but are working hard on their projects. They’re excited to show them off to the professors on Friday of next week and to the parents on Saturday. They’re learning a lot and have a lot to show for it; we all just need a nap right now! 😊
Cluster 5

This week we look back at week three where we took a field trip to the DMG Mori and plunged deep into the world of computer programming as students spent a lot of time working in the UNIX computer lab and robotics lab.

For the third week of COSMOS, the students of Cluster 5:
- Have begun their design and programming of LEGO Mindstorms robots
- Have modelled the biophysical behavior of random walk molecules in 2 and 3 dimensional space
- Learned to give and receive criticism as a integral part of the iterative design process
- Were challenged to pursue mentorship by Chief Surgery Resident at MedVet Medical & Cancer Centers for Pets in Columbus, Ohio, Katrina Castaneda (former COSMOS student).
Notable experiences from COSMOS Week 3:
- What is it like to work for a large robotics-based engineering company, DMG Mori
- The frustration and excitement of design projects
- Talent Show Friday Night (Dancers of Cluster 5)
- How to catch rare pokémon on campus during lunch!

Links to each student’s personal journals: huangsnths.weebly.com
Cluster 6

Cluster 6 is gearing up for their final week of COSMOS! The students have made significant progress on their projects and are putting together the pieces of their papers.

Graph Theory, taught by Professor Brad Ballinger, wrapped up this week. Students ended the course on Deterministic Finite Automata, a type of machine that accepts or rejects strings of input. These are represented by graphs and are also studied in Computational Theory courses.

They continue to advance their understanding of Combinatorics, Number Theory, and Probability in Professor Marx’s course. They have been enjoying presenting solutions to problems they work on in groups.

The students started their Knot Theory course this week with Professor Abigail Thompson and Post-Doctoral Researcher Nick Castro. They examine what it means to be a knot and what kinds of things we can do to a knot that doesn’t change when we change the knot. This week they got to play (ahem..learn) with play doh!

Students also got to visit the California Academy of Sciences this week. While they were there, they put their new understanding of perspective to use to create some fun photographs (see an example below).

In the final week, the students will complete their knot theory and combinatorics courses, finish up their papers, present their project to their peers, and take a trip to the UC Davis Bohart Museum of Entomology. See you at the closing ceremony!

On the field trip:
Perspective photo:

Learning with play doh:
Cluster 7

We blinked, and another week of COSMOS 2017 is behind us. The month is flying by far too quickly. During week three, students ramped up work on their research papers in preparation for their cameo lectures next week (there are “Oscar” statues to be won!). Monday morning, Dr. LeFebvre shared his expertise on the microbiology of Lyme Disease. Monday afternoon, students participated in the “hamburger lab”. As we BBQ’d a hamburger that had been inoculated with E. coli, students plated and cultured samples collected at various cooking times (don’t worry, the hamburger meat was not actually consumed). Tuesday morning, Dr. LeFebvre led a discussion about sepsis and meningitis, followed by a presentation on the microbiology, contraction, diagnosis, and vaccination against tuberculosis, a disease that kills millions of people annually worldwide.

Tuesday afternoon, veterinary pathologist Dr. Patricia Pesavento and her veterinary students facilitated a discussion and pathology “wet lab” exploring the physiological impact of various viruses, poisons, and diseases that they encounter during their practice. During this lab, students had plenty of hands-on experience with organ specimens, both from recent cases and preserved (be sure to ask about the lungs). After the pathology workshop, Cluster 7 went on a group outing to the newly-remodeled UC Davis bowling alley...turns out that we have a young professional bowler in the cluster (really!). Wednesday morning, students received a lesson from Dr. LeFebvre on tetanus and botulism, including a discussion about botulinum toxin, considered to be one of the most toxic substances with no known antidote (but therapeutically used as “Botox”).

In the afternoon, Dr. Erik Lauren, emergency room doctor at the UC Davis Medical Center, gave a very lively presentation on becoming and being a medical doctor, while sharing some amazing cases he has encountered while working in emergency medicine for nearly two decades. After Dr. Lauren’s talk, students participated in a very active cardiovascular activity, which left everyone soaked (ask your student about that). While Friday was spent mostly working on the various cluster projects, the evening talent show affirmed that Cluster 7 is a very talented bunch! It is hard to believe that we are entering the last week of COSMOS 2017. It has been an amazing month so far.
Cluster 8

Cluster 8 began the week with a trip to the Novozymes facility. Novozymes is a company that produces enzymes that other companies can use to enhance production of commercial products such as bread, cloth, and paint. We were given a tour of several of the company’s labs and facilities. Among these labs were multiple machines that isolated DNA molecules, filled sample wells at inhuman speeds, and maintained environments to mass-produce enzymes and host bacteria.

After lunch, we gathered in the computer lab for our writing and communications class. We worked on our projects, which consists of a single spaced 4 page paper, poster, and powerpoint presentation. We have one more week to finish this gargantuan task, and many of us have yet to write a single page! Then on next friday we get critiqued by the professors. Can you spell terrifying?!

For the later afternoon, we did our first lab under the direction of Dr. Velazquez. We worked in groups because as Forrest says “Science is all about collaboration”. Still wondering why we have individual projects but okay. In the lab, we synthesized amorphous silicon. The experiment involved exploding hydrogen gas! Pyromania!!! After another meal at the DC, students could enjoy the nightly activities of dodgeball and mug decorating.

Tuesday began with an in-depth introduction to the world of materials chemistry. We learned basic concepts in constructing solid-state materials, with particular attention to applications in photovoltaic cells or photocatalysts. An interesting aspect we focused on was nanotechnology; we learned how as materials are manipulated on the nanometer scale, we can drastically augment their efficiency by the subsequent changes in properties (such as bandgap and reactivity). It was exciting to learn about the hottest technologies and developments in the field, among these quantum dots, carbon nanotubes, and electron beam lithography.

In the afternoon, we had the opportunity to continue working on our projects in the writing and communications class. After that, we started water splitting and electrochemistry lab with Dr. Velázquez. In the first part of the lab, we observed water being split into hydrogen and oxygen in different tubes and watched the highly reactive hydrogen combust. In part two of the lab, we constructed galvanic cells and measured the voltages of each cell.

In the evening, we had “Destress Night” and Arboretum Marathon as recreational activities. For Destress Night, participating students each stuffed a sock with rice in order to make a neck pillow. They decorated the socks with colorful markers, and even had the option of adding soothing natural scents to the rice. The Arboretum Marathon was an opportunity for students to run 1.5 miles on a scenic route along the Davis Arboretum, with prizes for the fastest runners.

On Wednesday, students headed over to Room 172 for a lecture by the distinguished Professor Jesus Velasquez’s and his teacher assistant Forrest on solar energy conversion and electrolysis. Forrest began his 50 slide powerpoint with an introductory talk on energy storage and the general course of climate change in the past century. The class learned about the different ways of energy conversion, which includes biomass, wind, and solar energy. Finally, Forrest and Velasquez provided information of the economics of photovoltaic systems. After lunch, we ventured to the ARC to listen to a Distinguished Lecture from Dr. John Stachowicz, a Professor of Evolution and Ecology here at UC Davis. His lecture was focused on answering the question “Why is biodiversity important?”, and he guided us through his research on the intricate evolutionary balance of the California tidal ecosystem. We particularly enjoyed his research on
decorator crabs, which pick up pieces of coral, seaweed, and kelp and attach them to their backs as a form of camouflage. After the lecture, we undertook our second Velazquez lab, in which we took a macroscopic view of the concepts of renewable energy we learned in class by creating circuits powered by different green sources. The twenty-one of us were divided into three groups to work on wind-powered, solar-powered and hydrogen-powered circuits. For the solar circuit, we connected the circuits and ventured outside to power a fan with only a handheld solar cell. For the wind-powered circuit, we used the negative pressure inside the lab, designed to keep chemicals inside, to power three large fans and generate at least 1.3 eV to power hydrolysis from the third circuit. For the hydrogen circuit, we performed hydrolysis and then utilized the resulting hydrogen gas to power a fuel cell and connected it to a small fan and LED light. It was interesting to see the actual efficiency of these renewable energy sources in real life, instead of on paper. Finally, we looked at our amorphous silicon samples from the precious lab under a microscope to verify the identity of the molecules. Famous Davis student Ixchel Lopez stated that, “It [the lab] was cool.” After the lab, we enjoyed dinner and participated in evening activities, which included tie-dye and karaoke.

Thursday, we visited the Exploratorium in San Francisco. It was a fun experience to tour all the exhibits and interact with a variety of STEM applications, such as optical illusions, pendulums, sound tests, and even a pinball machine. Since we arrived early, we initially had nearly unrestricted access to all the attractions, but the place was soon filled with people. After the Exploratorium, we traveled a short distance and arrived at Gilead, a biopharmaceutical company that advances therapeutics and improves lives. During our visit, we received a free pair of safety goggles and had the wonderful opportunity to tour their HIV/AIDS lab, learned about the process of conceptualizing to selling the drug, and experienced the differences between the life of a scientist in academia and industry.

Friday, July 28th, Dr. Velazquez gave a lecture on fuel cells and batteries. Instead of giving a long winded powerpoint lecture for 2 hours, he presented us with documentaries along with his own supplementary information. It was very interesting to learn about the development and necessity of energy storage and conversion. After lunch and the writing and communications class, we will be going to the lab to create glow sticks. Peroxyacid acid produced from reaction between phenyl oxalate ester and hydrogen peroxide will decompose to carbon dioxide with a release of energy that will excite the dye. The dye will then return to ground state with the release of photons (fluorescence), making the mixture glow. The talent show on Friday night featuring the COSMOS students is sure to be a blast. All of the participants have been working hard to perfect their acts. There will be many fun acts ranging from unicycle riding to hula dancing. It is sure to be interesting.
Cluster 9

On Monday morning, we continued our studies with Dr. Lewis, learning how to convert differential equations into finite difference equations by manipulating a basic formula. Afterwards, he introduced the Fitzhugh-Nagumo model and allowed the class to explore various ways to program the multi-variable differential equations in R. In the afternoon, we learned about patterns of diffusion from Dr. Guy, implementing the mean squared displacement method. To model diffusion in real life, our class went outside and constructed hearts, peace signs, and spirals with matches. When we finished our creations, Dr. Guy lit them with matches, and we watched the fire and heat propagate from match to match as the properties of diffusion would dictate. After dinner, there was mug decorating and dodgeball. Some of us also biked downtown to watch the movies Guardians of the Galaxy Vol. 2 and Dunkirk.

On Tuesday, our cluster visited the California Academy of Sciences, where we got to explore various interactive scientific exhibits. In the aquarium tunnels, we witnessed fish swimming over us, and read about their quirks. Upon our arrival, most of our cluster flocked to the planetarium, where we viewed a George Takei-narrated film about the cosmos (the sky, not the acronym). Learning about these earth-like planets, the paths of comets, and the intricacies of our solar system left us intrigued and excited to explore the museum further. We had the chance to venture through the rainforest and see a myriad of butterflies flying all around us. Then we made our way to be shaken up by the Earthquake simulation modeled after the Loma Prieta earthquake from 1989 and the infamous Great San Francisco earthquake from 1906.

After an excitement-filled bus ride home, we were treated to a much needed de-stress night (after all the bus shrieking we endured), complete with aromatherapy sock pillows, while a few decided to de-stress by running around the Arboretum. With that calming end to a hectic day, we journeyed on to Wednesday.
On Wednesday morning we had another productive lesson on spacial dynamics with Professor Guy. After lunch, alongside all of the other clusters, we attended a lecture by guest speaker Jay Stachowicz about the biodiversity on earth and its importance to ensure that ecosystems thrive. Despite his unfortunate post-lunch time slot, Dr. Stachowicz kept us wide awake with his fascinating ecological research, but what really energized us was the ice cream that we got afterwards.

Then, after 2 weeks of lectures, we got to apply what we had learned to the beginnings of our final projects, the culmination of our learning, the purpose of our COSMOS lives! With the guidance of our brilliant professors, TA’s, TI’s, and peers, we began the daunting journey ahead. In our project groups of 3 or 4 students, we had our first class work period during which we researched, modelled, and programmed until we successfully finished the introductory steps of our projects. You’ll have to wait to see the outcomes next weekend!

The fun didn’t stop there. After class, we transitioned from intensive math models to colorful tie dye t-shirts to screaming off-key at the top of our lungs at karaoke night. At the tie dye activity, we enjoyed making unique designs on white t-shirts and on our knees by first splattering shirt dye on the grassy quad and then unknowingly kneeling down on the same area.

Another eventful day flashed before our eyes; we all certainly have empirical evidence for the old adage that time flies when you’re having fun!

Thursday, July 27

\[
\text{Values of Day written as a function of time}
\]

\[
\text{Day}_{T=0} = (\text{Hungry} + \text{Sleepy} + \text{Confused} + \text{Bored}) \text{ kids}
\]

\[
\text{Day}_{8:00\ AM\ to\ 8:50\ AM} = \text{Day}_{T=0} + \text{Breakfast} - \text{Hungry}/3
\]

\[
\text{Day}_{8:50\ AM\ to\ 9:00\ AM} = \text{Day}_{8:50\ AM} + \text{Morning\ Announcements} + \text{Ali} - \text{Sleepy}
\]

\[
\text{Day}_{9:00\ AM\ to\ 11:30\ AM} = \text{Day}_{9:00\ AM} + \text{Lecture} * \text{Dr. Guy} * (\text{Waves} + \text{Patterns}) - \text{Confused}/2
\]

\[
\text{Day}_{11:30\ AM\ to\ 12:40\ PM} = \text{Day}_{11:30\ AM} + \text{Lunch} - \text{Hungry}/3
\]

\[
\text{Day}_{1:00\ PM\ to\ 2:00\ PM} = \text{Day}_{12:40} + \text{Project time} * \text{Professors} + \text{Confused} * e^x
\]

\[
\text{Day}_{2:00\ PM\ to\ 3:30\ PM} = \text{Day}_{2:00} + \text{Project time} * \text{Professors} - \text{Confused} * e^x
\]

\[
\text{Day}_{3:30\ PM\ to\ 5:00\ PM} = \text{Day}_{3:30} + \text{Project time} * \text{Mr. Gonzalez} - \text{Confused}/2 + \text{Educated}
\]

\[
\text{Day}_{5:00\ PM\ to\ 6:00\ PM} = \text{Day}_{5:00} + \text{Dinner} - \text{Hungry}/3
\]

\[
\text{Day}_{6:00\ PM\ to\ 10:30\ PM} = \text{Day}_{6:00} + \text{Volleyball} - \text{Bored} + \text{Happy} * e^x
\]

\[
\text{Day}_{10:30\ PM} = (\text{Happy} * e^x + \text{Educated}) \text{ young adults}
\]

\[
\text{These are equations}
\]

\[
\text{They’re as good as our poem}
\]

\[
\text{Our great creations}
\]
On Friday, we spent the whole day, minus lunch, working on our projects. In the morning, Professor Tim Lewis, Professor Sebastian Schreiber, Professor Bob Guy, TA Sam Fleischer, and TA Katy Jarvis were all here to help us with questions we had and to further explain the topics we had chosen to research and model. After lunch, only the TAs and Professor Guy were available for clarifying things. Professor Lewis stopped by during the last hour to say goodbye and help us for the last time, as Friday would be his last day teaching for COSMOS this year. We took many pictures with Professor Lewis right before he had to leave to catch his flight. The evening activity is the talent show. All the acts were really enjoyable to watch, and overall it was a fun experience.