AN EVALUATION OF THE
2018 GLOBAL ENVIRONMENTAL MICROBIOLOGY (GEM)
SUMMER COURSE FOR UNDERGRADUATES

Executive Summary

Prepared for:
Center for Dark Energy Biosphere Investigations (C-DEBI)

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INTRODUCTION

The Center for Dark Energy Biosphere Investigations (C-DEBI) NSF Science and Technology Center offered a three-week summer program at USC and the Wrigley Marine Science Center on Catalina Island: the Global Environmental Microbiology (GEM) program. From early to late June, 2018, 16 undergraduates attended lectures and lab classes, conducted hands-on research, and participated in field trips and social activities. The instructors for the class were Professors John Heidelberg and Eric Webb, the program coordinator was Gwen Noda, and the TA was Gerid Ollison.

Methodology

A few weeks before they arrived for the program, students completed an online pretest survey, designed in conjunction with GEM program staff; questionnaire completion took an average of 47 minutes. Questions included goals and concerns about the upcoming summer course, career plans, and familiarity with the course content, including 12 short-answer science concept questions.

At the end of the course, students completed an online posttest survey, also designed with the GEM program staff. Questionnaire completion took an average of 42 minutes. Questions included satisfaction with the course, course impact on knowledge and career goals, knowledge of course content, and suggestions for course improvement.

Responses to the 12 short-answer science concept questions were coded by the course TA for level of understanding. Pretest and posttest questions were coded at the same time, and the TA did not know if each answer was from the pre- or the posttest, nor did the TA know the identity of the student responding.

Participant Demographics

All 16 participants completed both the pre- and posttest surveys, for a completion rate of 100%, although one participant did not complete the science concept questions. Participant demographics were as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
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<th>Percentage</th>
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<tbody>
<tr>
<td>Female</td>
<td>62%</td>
<td>African American</td>
<td>6%</td>
</tr>
<tr>
<td>Male</td>
<td>38%</td>
<td>Alaskan Native</td>
<td>--</td>
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<tr>
<td>Rising:</td>
<td></td>
<td>Asian</td>
<td>19%</td>
</tr>
<tr>
<td>Sophomore</td>
<td>44%</td>
<td>Hispanic</td>
<td>44%</td>
</tr>
<tr>
<td>Junior</td>
<td>44%</td>
<td>Native American</td>
<td>6%</td>
</tr>
<tr>
<td>Senior</td>
<td>12%</td>
<td>Native Hawaiian/Pacific Islander</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>38%</td>
</tr>
<tr>
<td>Other * (students could choose more than one ethnicity)</td>
<td>6%</td>
<td><strong>&quot;Filipino/Iranian&quot;</strong></td>
<td><strong>&quot;Filipino/Iranian&quot;</strong></td>
</tr>
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Colleges and universities represented by the students include:

**2-year colleges:**
- Antelope Valley College, Lancaster, CA
- Cabrillo College, Aptos, CA
- El Camino CC, Torrance, CA (2)
- Kapiolani CC, Honolulu, HI
- Nashville St. CC, Nashville, TN
- Naugatuck Valley CC, Waterbury, CT
- Prince George’s CC, Largo, MD
- Riverside City College, CA
- San Diego City College, CA
- Santa Monica College, CA
- Santa Rosa Junior College, CA

**4-year colleges:**
- CSU Channel Islands, Camarillo, CA
- U. of Hawaii, Manoa, HI
- U of South Carolina, Columbia, SC
- Xavier U. of Louisiana, New Orleans, LA

All of the students had already declared an undergraduate major—all declared majors were in a STEM field, and most related to the biological sciences. All say they probably (13%) or definitely (88%) hope to have a career in science.

This document provides a summary of the responses. Complete data for both the pre- and posttest surveys are provided in the Appendix. Participant comments were copied directly from the online survey and were lightly edited for spelling and punctuation.
SUMMARY OF FINDINGS

Overall, this eighth summer of the GEM program was again a success, with appreciative participants who felt the program impacted their educational and career paths.

1. Satisfaction with the GEM program

- All students felt the course was a worthwhile experience and would recommend it to others.
- Hands-on research experience that they couldn’t get at their home institution was a huge benefit.
- Students also enjoyed *each other*. Meeting a group of like-minded colleagues was a valuable new experience.

Suggestions:

- Many students felt the labs and lab manual were disorganized.
  - The new course TA may need more support in planning and implementing this component of the program.
- Pre-program information is often a low-rated aspect of the program. Students also would especially appreciate a more specific itinerary so they can know what to expect from the program.

2. Impact on participants’ career goals

- For the majority of students, the program impacted their educational and career goals. Although all began the program with an interest in a scientific career, this program cemented that interest and gave them direction as to how to achieve that goal. Mentoring by the GEM staff, as well as others they met at Wrigley, furthered this benefit. The career panels were especially beneficial this year as they included graduate students.

Suggestions:

- C-DEBI should continue to follow-up with program alumni to track their career progress and determine how the GEM program continues to influence their educational and career choices.
3. **Impact on knowledge of course content**

- Student’s understanding of many of the relevant scientific concepts grew significantly as a result of the course.

**Suggestions:**

- The program should examine the content areas in which students have only a simplistic understanding, to see if the curriculum should be modified.

4. **Inclusion and diversity**

- Students valued the program’s focus on diversity and inclusion. They felt the program celebrated diversity beyond ethnicity, including culture and region.

- About half the students already had some diversity training before arriving at the program.

**Suggestions:**

- There was a small group of students whose politics did not agree with the group. This created an uncomfortable situation for some students. The program could include political differences in the diversity seminar.
COMPARING THE GEM PROGRAM TO STUDENTS’ EXPECTATIONS

All students said the program either “met” (13%) or “exceeded” (87%) their expectations. No student said that the program “did not live up to their expectations.”

Many participants reflected on how much they enjoyed the **people** in the program—their classmates, the professors, and the staff.

→ “I fell in love with everything. The people, the lectures, the instructors, and all the staff who made it possible.”

→ “I didn’t think I would meet such a great group of people and authoritative figures that would care about me so much.”

→ “I think what contributed the most was that everyone got along so well together and we all strived to help each other understand concepts that were unclear at the beginning of the course.”

→ “I didn’t expect to meet so many great people from such different backgrounds.”

→ “It was a lot smaller in the sense that we got one on one with instructors and the staff here! I like the small campus feel of Wrigley, it allowed us to network and learn from professionals as well as other students here.”

Several others commented positively on the **hands-on experiences** and **field work**.

→ “The GEM program introduced to real life situations such as sampling on a boat that I would have never done at my home institution. It definitely was a great experience.”

→ “The GEM program differed from what I thought would just be research. While it wasn’t exactly research the various expansive lectures and lab activities - as well as just having access to a lab for our own curiosity - greatly exceeded what I first expected coming to the island.”

A few students said they **learned more** than they thought they would.

→ “I did not expect to learn this much, to come away with so many new skills and abilities. This course has prepared me more than anything to succeed in the world of science.”

However, a few students expected either higher-level content or even more hands-on time.

→ “I expected it to be a little bit more of a higher level course.”

→ “I expected more of lab work with specialized research experience but it was more of lecture and presentation time.”
MOST SIGNIFICANT PART OF THE COURSE FOR STUDENTS

Students derived a variety of benefits from the GEM course.

- **Making interpersonal connections**—with faculty, staff, and colleagues—was a valuable aspect of the experience.
  
  → “Talking with the professors and TA. I don’t know many people in the world of academia outside of my school, so having access to these people who knew so much gave me an enormous amount of information regarding my career choices and possibilities, as well as their each individual unique perspective on life.”
  
  → “The connections I made with my fellow students and instructors. It’s rare to get 3 weeks to focus on learning and having the opportunity to learn from so many different people was incredible.”
  
  → “Building strong, genuine relationships with not only my peers, but my professors and TA.”

- **Learning hands-on research skills** was also a benefit of the GEM course. Several said they would not have access to these skills at their home institution.
  
  → “I really enjoyed the labs. I loved the actual field research and how close it is to the profession I am interested in. I had never worked with a lot of the lab materials that I was exposed to during the GEM course.”
  
  → “The use of equipment was significant to me because I probably would never have the chance to use them at my school.”
  
  → “Research and learning the skills to operate the modern scientific instruments.”
  
  → “The opportunity to use lab equipment that I normally don’t have access to. This kind of experience is invaluable!”

- The **career panels** were also a benefit of the GEM course.
  
  → “The panels!!!! I’ve taken so much from hearing others tell us about their life and how they got to where they are now! That’s what helped me shape my goal!”
  
  → “The most significant part was the grad school panel. It was interesting to hear the stories of others, particularly of minorities, about their experiences as an undergrad and grad student. They helped clear a lot of worries that I had about grad school.”

- And, of course, students learned **new content** from GEM.
  
  → “It was a mix of the lectures and lab contents. I got to learn about things I never thought about and use what I learned in lectures in the lab, and think about my results.”
  
  → “I liked the lecture part, learning new things about environmental ecology.”
Students were quite satisfied with the educational content of the GEM program.

- The **academic course** received very strong scores; most students (94%) rated it an “8” or higher on a 10-point scale and half gave it a perfect “10”. The professors made sure the students understood the complicated material. Just one student thought the lectures were a bit too long and too advanced.

  → “Extremely grateful for receiving a USC education for free and having my professors actually know me.”
  → “Very informative! Instructors very willing to help us understand all material!”
  → “A little fast, but it’s understandable why and it was bearable. But I would have gained more information if this was starting from the basics. But it taught me how to hit the ground running, even if I didn’t know anything at first I kept trying, and eventually it all made sense.”
  → “The professors explained the information in a way that I understand and didn’t rush just to get through the lecture. They actually took the time to make sure everyone understood and I really appreciated that.”

- Students appreciated the **research experience**, with most (81%) rating it an “8” or higher on a 10-point scale, and 44% rating it a perfect “10.” Students appreciated learning new techniques and the hands-on fieldwork. However, a few students would have wanted more field work than just sampling off the dock. Also, several students complained that the labs were poorly organized (see page 19 for more comments on labs).

  → “I loved that we were able to do everything in the lab including making our own gels for PCR/ARISA labs.”
  → “Perfect! I had a ton of fun doing the labs (that I was able to do anyways) and learned so much more than my microbio class at El Camino was able to teach me.”
  → “Sampling from the dock was fun but maybe we can have different types of field sampling.”
  → “Could have been a little more varied. Most of the field work was just water sampling. But all of us are water sampling pros now!”
  → “The lab manuals were sometimes hard to follow even if I tried to read them beforehand.”
  → “Could’ve been more organized and structured. I understand our TA was new to this course but should still give us a heads up in change in equations or protocol steps.”
The “caring” and “respectful” program coordinators also received very positive ratings; all students rated them an “8” or above, with 87% rating them a perfect “10.”

→ “They were all so kind and willing to help. It was nice to know that we had people that were willing and able to help us whenever we needed it.”

→ “We love you guys!! Gwen is sooooo thoughtful!”

→ “Respectful and very caring! Thank you for the brownies, Gwen!”

The mentoring that students received was “invaluable” and “respectful.” All students rated it an “8” or higher, with 56% giving it a perfect “10.”

→ “The perspectives I gained from this program have been invaluable. I couldn’t be more thankful to the TA and professors for everything.”

→ “Gerid was absolutely amazing and someone I feel I could reach out to with questions in the future. Eric and John were also incredible resources and all of the panels were very helpful.”

→ ”They were always respectful and seemed genuine in helping out!”

→ “Everyone was so great. Gerid, Eric, Gwen and John were so caring and genuinely wanted us to get the most out of the program.”

The pre-program information received mixed ratings; half the participants rated it an ‘8” or higher. While some students found it helpful or sufficient, many others would have appreciated a schedule before the program began.

→ “Basically explained everything that needed to be explained.”

→ “Very informative and helpful!”

→ “We were not aware of our schedule until after we got on the island.”

→ “I would've liked to have had access to the schedule before the course actually started and maybe know a little about the people who were going to participate in the program. I was asked several times what we were going to be doing during the program and I didn't really know what to answer.”

### PROGRAM RATINGS: COORDINATION AND SUPPORT

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<thead>
<tr>
<th></th>
<th>Mean (0-10)</th>
<th>% 8,9, or 10</th>
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<tbody>
<tr>
<td>Program Coordinators</td>
<td>9.8</td>
<td>100%</td>
</tr>
<tr>
<td>Mentoring</td>
<td>9.3</td>
<td>100%</td>
</tr>
<tr>
<td>Pre-program Information</td>
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<td>50%</td>
</tr>
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</table>
PROGRAM RATINGS: OVERALL, SOCIAL/EXTRACURRICULAR ACTIVITIES, AND CAREER PANELS

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<tr>
<th></th>
<th>Mean (0-10)</th>
<th>% 8, 9, or 10</th>
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<tbody>
<tr>
<td>Overall Program</td>
<td>9.8</td>
<td>100%</td>
</tr>
<tr>
<td>Social/Extracurricular activities</td>
<td>9.7</td>
<td>100%</td>
</tr>
<tr>
<td>Career Panels</td>
<td>9.4</td>
<td>94%</td>
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- The **program overall** scored extremely well—all students rated it an “8” or higher and 75% rated it a “10.” It was an “awesome” and “unforgettable” experience.

  → “This experience changed my life. I couldn’t be more thankful.”
  → “I loved the experience. I recommend to all students interested in the sciences and for minorities. A very safe, inclusive environment.”
  → “Unforgettable experience.”
  → “This program really helped me to get some great research and fieldwork experience while learning and making some connections.”

- Students were extremely pleased with the “interactive” and “fun” **social/extracurricular activities** in the program. All students rated them an “8” or higher, 69% rated them a “10.”

  → “I loved the snorkeling, kayaking, volleyball, and just free time to get to know the other participants and make connections.”
  → “They were fun and we got to do our own thing most times.”
  → ”Fun bonding experiences!”

- Students appreciated the “inspirational” **career panels**; almost all students (94%) rated them an “8” or higher, with 69% rating them a perfect “10.” One student wished there had been more information about medical professions.

  → “There were people from all walks of the STEM field. Seeing their path of life and how it twisted and turned to get them to where they are now only cemented my career goals.”
  → “The best! Everything was insanely helpful and inspirational.”
  → ” Very instructive and I found out a lot of things about grad school that I didn't know.”
  → “I wish there were more pre med people and not just graduate students because I really wanted to get some information and make connections.”
Students' attitudes toward the program were extremely positive.

- All students would strongly recommend the program to other students.
- All students agreed (almost all of them, strongly) that the GEM program was a worthwhile way to spend their summer.
- All students agreed (almost all of them, strongly) that the GEM program would help their future career.
- All students agreed (almost all of them, strongly) that the program introduced them to new career options.
Students’ responses were coded by the TA, based on a rubric created by the course instructors, as follows: 0=“I don’t know,” “Not sure”
1=Incorrect answer
2=Aspects correct and incorrect
3=Correct information, simplistic
4=Correct information, understanding of complexities

Students showed a more sophisticated understanding of targeted science concepts after completing the course. Note that by the end of the course, more than half the students had at least a simplistic, if not complex, understanding of almost all the targeted content.

- Students came to the course with little exposure to course material, with the exception that about one-half of students knew some microbiology/molecular biology basics (DNA/RNA structure & function, diversity vs. abundance, bacterial growth, the difference between viruses and bacteria, and prokaryotic vs. eukaryotic cells). While students showed improvement in some of these basic areas, change was statistically significant only for bacterial growth.

- Students demonstrated statistically significant learning of most other course concepts. Knowledge gain was largest for content for which most students had no previous exposure: bioluminescence and quorum sensing, a protocol to define microbial diversity, oxygen’s effect on ocean microbes, nitrogen cycling, cyanobacteria and ocean acidification.

- For anthropogenic nutrient inputs, the change in students’ knowledge approached statistical significance ($p=.07$).
Even before entering the program, most or all of the GEM students had planned to continue with their science education. All planned to take more science classes in college and apply to a 4-year college if currently at a 2-year college, and almost all planned to major in science at a 4-year college and have a career in science. In addition, most plan to pursue a graduate degree in science. These plans did not change significantly as a result of the GEM program.

• After the GEM program, students were significantly more likely to plan to do research in a professor’s lab (86% vs. 100%).

• The program did not significantly influence students’ interest in a lab-based research career. However, after the program, students were significantly more interested in conducting field research as part of their career (81% vs. 93%).

• While the program did not influence students’ interest in teaching K-12 science, interest in teaching science at the college level increased significantly (25% vs. 44%).

• See the next page for students’ comments on how the program influenced their educational and career plans.
IMPACT ON EDUCATIONAL GOALS

“How much has this program influenced your educational goals?” (posttest)
0-100, 0=“none”, 90=“new goal”

<table>
<thead>
<tr>
<th>Impact Score</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>100</td>
<td>31%</td>
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<tr>
<td>71-99 (“New goal”)</td>
<td>38%</td>
</tr>
<tr>
<td>51-70 (“Significant changes”)</td>
<td>19%</td>
</tr>
<tr>
<td>31-50 (“Some changes”)</td>
<td>6%</td>
</tr>
<tr>
<td>&lt; 30 (“Very little”)</td>
<td>6%</td>
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(Mean impact score = 80, “significant changes”)

All students felt that the GEM program impacted their educational goals at least somewhat, and more than two-thirds (69%) said the program has given them a new goal. For some, the program pushed them toward pursuing an advanced research-based degree. For others, the program showed them career options that resonated with them.

Students’ educational impact ratings are indicated in parentheses after their direct quote below.

“New Goal”:

→ “It opened my eyes to different aspects of the biology field. I found that I’m very interested in learning more about biology specifically bioluminescents. I definitely am now interested in pursuing a higher degree after my bachelors.” (100)

→ “I came into the program contemplating majors and not knowing what my next step was and now I know I want to do my undergrad in biology and after that keep pursuing a higher education. I've set a goal for myself and now that I have this goal and I can see myself putting the pieces together and actually getting to where I want to be.” (90)

→ “I am still focused on my career goal of being a doctor, but my mind is much more open to the research world now, I had never considered research as something I'd want to do, but now…” (85)

→ “It has given me a better idea on the route I want to take as a grad student as well as how to accomplish those goals. Our panels were so encouraging and inspiring and made me very excited to get home and get involved in my new school! I feel like this program has given me a lot of resources I was never aware of!” (80)

“Significant Changes”:

→ “This program has introduced me to new areas of marine science. In the beginning, I was unsure about what I really wanted to focus on. I never thought about specialized areas, such as microbiology, that are within marine science. This program allowed me to focus in this one area and definitely caught my interest as one area that I may focus on in the future.” (70)

→ “Allowed me the opportunity to explore other STEM fields and possibly see connections with marine science or microbiology with my major.” (70)
“Some Changes”:

→ “My goals are the same, but my strategies for getting there and my belief in my ability to get there have changed drastically.” (50)
Most students felt the GEM program provided a learning environment that is respectful of diversity and inclusion. Students appreciated the diversity of the program participants, but some commented that a few students did not respect the political views of others.

→ “I don’t know how they did it, but 16 people from all parts of the U.S clicked in the first couple days. Everyone was extremely kind and offered their own perspectives in a respectable way.”
→ “Everyone was respectful towards one another despite their cultural differences. For once, I felt I belonged in academia. I was able to bond with others who had the same dreams and fears as a first generation college student and a minority.”
→ “The program does a great job. Personally, it opened up a lot of perspectives on people from other backgrounds than mine, and showed the importance of talking about it.”
→ “Most of us got the memo, but a few were still hard headed when it came to looking at and respecting the views of others.”
→ “For the most part everyone was extremely diverse and welcoming! However there were some participants that offended others during the course of the trip when politics came up.”

Most students did not experience any racial tension or discrimination. However, there were a few moments of discomfort for some students, based on political differences.

→ “There was a group of 3 white, more privileged students who distanced themselves from the group because they took the discussions about diversity and opportunity as criticisms of their effort to get there.”
→ “I did feel somewhat singled out as an oddball after some people finding out there are certain groups I am a part of which was completely unnecessary. Many times as well the group made uncomfortable awkward situations outside the classroom.”
→ “Myself and another classmate had a conversation with someone who identified as a conservative republican, but all parties kept the conversation respectable and productive, in the end we settled to agree to disagree.”

Some students felt that the GEM program was more respectful of diversity and inclusion than is their home institution; for the rest, their home institution is comparable to GEM.

→ “My home institution is predominantly white and Latino, with most people being from around this area. It was great to have the opportunity to hear about the experiences of people of different races and backgrounds from all around the country.”
→ “My home institution lacks a bit of diversity. As a minority, I felt excluded and unsure of my path as a student. However, the GEM program showed me that there are others like me who strive to succeed in academia. That as minorities, we can do it too.”
→ “There was more diversity in GEM program, and it was also great that we got to discuss the diversity problems.”
→ “My experience here at the GEM program was different than my HBCU because there were people of all different ethnicities here. Also I was able to use a lot of lab equipment that my school can’t afford.”
→ “There is definitely more diversity in my college campus but the GEM course was also a diverse program because I was able to meet people outside of the state.”
→ “Not too much of a difference. My school is already very diverse and inclusive.”
ADDITIONAL CONTENT STUDENTS WOULD HAVE LIKED IN THE COURSE

Students were asked if there was anything else they would have liked to learn as part of the GEM course.

• Some students requested more information about specific topics within the field.
  → “Analyses of microbes in sediments.”
  → “Megafauna.”
  → “I wish I would have learned more about the different protists and look under a scope to find them.”
  → “More details on Genomics.”
  → “More about the ecosystem dynamics.”
  → “I would've loved to have had more time to have the historical lecture that Dr. Heidelberg was planning on giving or to hear about Dr. Webb's further lectures.”

• A few students expressed interest in broader topics.
  → “I would have liked to learn more about conservation and how to help address environmental issues in the world.”
  → “I would have liked to learn a little more about microbes in relation to humans.”
  → “Quorum sensing, viral activity, a viral lab.”
  → “I would have loved to learn more about molecular biology than microbiology.”
STUDENTS’ SUGGESTIONS FOR IMPROVING THE GEM COURSE

Many students felt the labs and lab manual could be better organized.

→ “Be more prepared at lab, our equipment was limited we all had to share a lot of equipment.”

→ “A lab tech to help the TA and redone lab protocols. The labs were unorganized and the protocols were outdated.”

→ “More organized labs. Sometimes it seems like no one new what they were doing... Protocol is not always followed or accurate.”

→ “The labs were fun! However, to make it more efficient, it would be best to have some sort of pre-lab session to fully understand the process of the labs that are to be conducted.”

→ “I think the lab manuals should be a little more easy to follow and broken up.”

→ “Perhaps better prepared labs with more equipment to cater to all groups.”

→ “The Lab lacked supervision, and organization. I would suggest to demonstrate protocols to the group before letting us work. People with less experience than I have, they had difficulty to understand and do it safely.”

→ “Lab manuals that are easier to read.”

Others had suggestions about the final presentations.

→ “More time for the final presentation! Or at least giving students an idea of the topics early on so that they can mull it over throughout the course.”

→ “More one on one talk and science conversation with the professor than just presenting. I feel like some people have the knowledge but due to stage fright, they couldn't express their feeling properly.”