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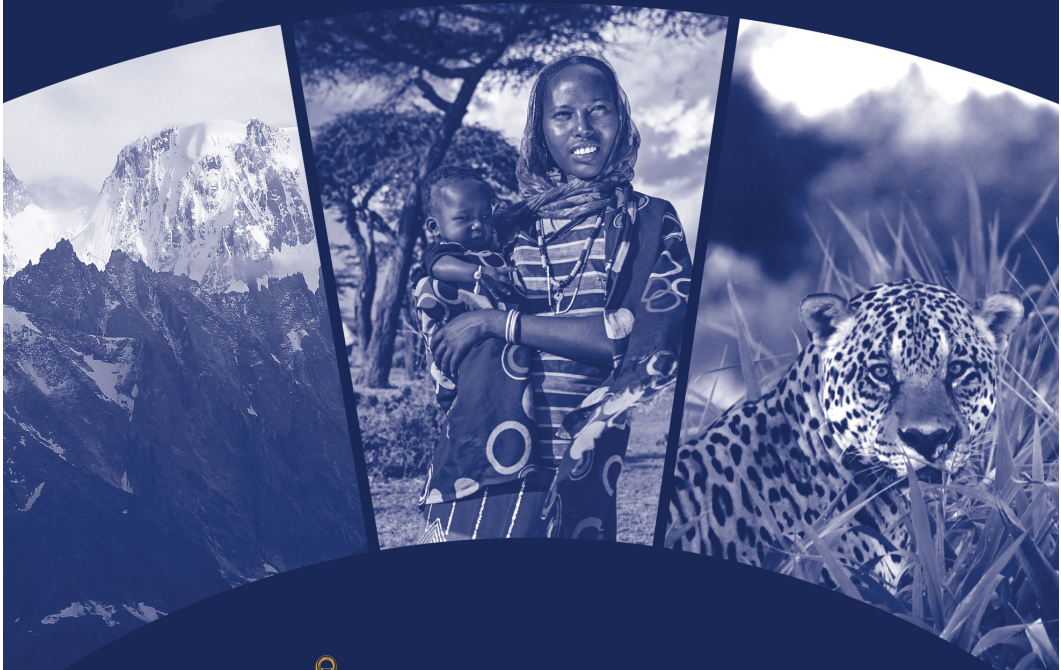

PHI THETA KAPPA
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HUMAN MICROBIOMES AND HOW THE EARTH WORKS

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ABSTRACT
Life on Earth is dependent on a myriad of microorganisms. Bacteria in soil and water, the Earth microbiome, provide nutrients for plants through decomposition. A growing body of research indicates bacteria living in the human body, the human microbiome, are essential for good health. We explored the Earth and human microbiomes to add new findings to these areas. In addition to our discoveries, we actively involved our team members in the scientific process. Collaborating with college and community leaders, our leadership team identified projects and monitored their progress. The projects involved literature reviews, campus and community awareness, laboratory and field research, and teaching over 500 pre-college students. We collected human microbiome samples from attendees at the Phi Theta Kappa regional leadership conference, in the community, and at an event on campus called "Honors in Action (HIA) Day." We explored aquatic microbiomes and published our original research on the Earth microbiome. Our team shared the sentiment that "you don't need to be a scientist to understand the concept of microbiomes. Science can be fun for everyone."

OBJECTIVES
The project's primary goal was to raise awareness about our natural environment and the importance of the microbiome to our health and to the Earth. Our efforts included original laboratory and field research to determine the role of the microbiome in specific environments. Throughout this project, we maintained our desire to be citizen scientists and to do a technically challenging project so that we could enhance our skills and knowledge.

ACADEMIC INVESTIGATION
In 2016, President Obama announced an initiative to research microbiomes that shape life on Earth — including those in plants, animals, water, soil, and air. And a *New York Times* article, "Gut Makeover for the New Year," suggested engineering one's microbes could lead to good health. We were inspired by these current events that natural microbial populations could be engineered to combat diseases, grow more food, and even reduce greenhouse gases. Social science, business, and science majors wanted to learn more about this.

As we learned about microbiomes, we wanted to contribute to scientific knowledge as citizen scientists and include the community as citizen scientists to encourage consumers to look at the science behind advertising claims.

CONCLUSIONS
Natural services are the processes carried out by living organisms that support all life. Humans cannot survive without the natural services provided by many other species, including microorganisms. In 1885, Louis Pasteur said, "Life would not long remain possible in the absence of microbes" because microbial decomposition recycles chemical elements. The microbes that live in a specific environment are called the microbiome. Microbes that live in the soil, on plants, in insects, and in the most widely varied habitats on Earth make up the Earth microbiome. With the recognition that environmental change resulting from human activities is causing a decline in biodiversity, attention is being given to understanding how changes in biodiversity alter

natural services (e.g., decomposition, detoxification, nutrient availability) provided by microbes. The importance of the microbiome was demonstrated when fallow farmland was engineered to become grassland by adding grassland microbiome. The National Microbiome Initiative was launched in 2016 to expand our understanding of the role microbes play in different ecosystems, including soil, plants, water, and the human body. Microbial nitrogen cycling in agriculture is well known, but very little is known about the overall function of the Earth microbiome.

An adult human is composed of about 30 trillion body cells and harbors another 40 trillion bacterial cells — the human microbiome. We read scores of articles on the human microbiome. An imbalance in the microbiome, especially in the intestine, may contribute to obesity, diabetes, and allergies. Probiotics are live microorganisms that provide a health benefit when administered to the host. Probiotics have been studied in recent decades as a way to engineer a person's microbiome to promote health and prevent or manage diseases. Engineering the gut microbiome by transplanting fecal bacteria is being used to treat ulcerative colitis and intestinal infections. In 2013, the FDA recognized fecal transplantation as a new drug, leading to a surge in the sales of probiotics. Probiotics are advertised to improve one's health, cognition, and even beauty. Crawford concluded that consumers choose probiotics for their health-giving qualities rather than taste or sustenance. However, even with encouraging research regarding the human microbiome and health, a great deal is still unknown. Experts caution that there is not enough evidence to recommend that consumers engineer their microbiomes with probiotics.

ACTION

Throughout the year, we collected nasal swabs to determine the presence of methicillin-resistant Staphylococcus aureus bacteria (MRSA) in the population. We collected 217 samples from community groups. The collecting was always preceded by a presentation on the human microbiome. We presented our research numerous times. Members prepared and presented several workshops for middle-school children. Preparing the workshops required developing hands-on activities and holding several practice sessions.

Our Earth microbiome testing included determining the metabolic capabilities of microbes in environmental samples. In this process, Community Level Physiological Profiling, we grew bacteria to determine what they metabolize. The breadth of metabolic capabilities is an indication of how much pollution or disturbance an environment can handle. During the spring semester, soil microbiome teams collected soil samples from the roots of invasive plants and compared the microbiomes with that of native plants. Another team collected 25 samples along an urban stream that flowed through a city. We analyzed the samples to determine the effects of urbanization on the stream microbiome. In the fall, another team analyzed a stream that flowed through a different watershed.

In the spring, the air team investigated the effect of human habitation on room-air microbiomes. The team collected and analyzed 75 air samples from a variety of campus rooms, before and after occupancy. During the summer, an ocean team collected 12 samples at different depths in the Pacific Ocean and analyzed the microbiome. We contributed our information on the microbiome to the Pier Project.

IMPACT

We found that 3.7% of those surveyed carry MRSA. Our findings were presented to nearly 4,000 attendees at the National Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) conference in October. At this science conference, we won the Microbiology Award.

We also presented to 100 attendees at the College Research Symposium in May of 2017. And chapter officers shared the HIA-Microbiome project with the 125 attendees at the Phi Theta Kappa Regional Fall Leadership Conference. Additionally, 32 conference attendees contributed

their nasal swabs to our MRSA survey. Nearly 100 students visited our HIA Day on campus and throughout the school year; and, we led 20 hands-on teaching labs for over 500 middle-school students. This involved nearly 30 members going to middle schools. We prepared and brought all the necessary supplies. The workshops "Are all bacteria bad for you?" and "Marvelous Microbiology" were rated 4.2 on a scale of 1-dull to 5-fantastic.

The chapter is identified in the "College's Communities of Practice Initiative," and the college president in her newsletter recognized our work as servant leaders. We were one of only three presenters that the SSF Literacy Coordinator invited to present at the Fall Family STEM night. The City of South San Francisco nominated the chapter for the 2018 California Park and Recreation Society Service Award.

RESOURCES

Crawford, P., Brown, B. J., Nerlich, B., & Koteyko, N. (2010). "Nutritional altruism and functional food: lay discourses on probiotics." *Sociology of Health & Illness*, 32(5):45-760.

This article made us aware that consumers do not agree on whether probiotics are natural or engineered foods.

Duranti, S. (2017). "Obesity and microbiota: an example of an intricate relationship." *Genes & Nutrition*, 12(8). DOI: 10.1186/s12263-017-0566-2.

Duranti's article taught us about the complexities of human genetics, microbes, and nutrition.

Garbarino, J. and Mason, C. (2016). "The power of engaging citizen scientists for scientific progress." *Journal of Microbiology & Biology Education*, 17(1), 7-12.

Gabarino and Mason Informed our plan for engaging the community in our project.

Kowalski, K., Bacon, C., Bickford, W. A., and Wilcox, D. A. (2015). "Advancing the science of microbial symbiosis to support invasive species management: a case study on phragmites in the Great Lakes." *Frontiers in Microbiology*, 6. doi.org/10.3389/fmicb.2015.00095.

This article gave us ideas for investigating the microbiomes of invasive species in our area.

Lagenheder, S. (2010). "Bacterial biodiversity-ecosystem functioning relations are modified by environmental complexity." *PLoS One*, 5(5). DOI: 10.1371/journal.pone.0010834.

Lagenheder taught us how to determine diversity, which we applied to our Earth microbiome research.

Miller, L. (2015). "Probiotic claims for gastrointestinal conditions: Stretching the truth?" *Journal of Dietary Supplements*, 12(3):251-264.

This is one of several articles that provided insight into the unregulated probiotic industry.

Moran, M. (2015). "The global ocean microbiome." *Science*, 350(6266). DOI: 10.1126/science.aac8455.

The article describes the need to investigate metabolic relationships between microbes in the ocean; encouraged us to do field research on the ocean microbiome.

Thomas, S., Izard, J., Walsh, E., Batich, K. Chongsathidkiet, P., et al. (2017). "The host microbiome regulates and maintains human health: A primer and perspective for non-Microbiologists." *Cancer Research*, 77(8), 1783-1812.

This article introduced us to the essential contributions of microorganisms to human health.