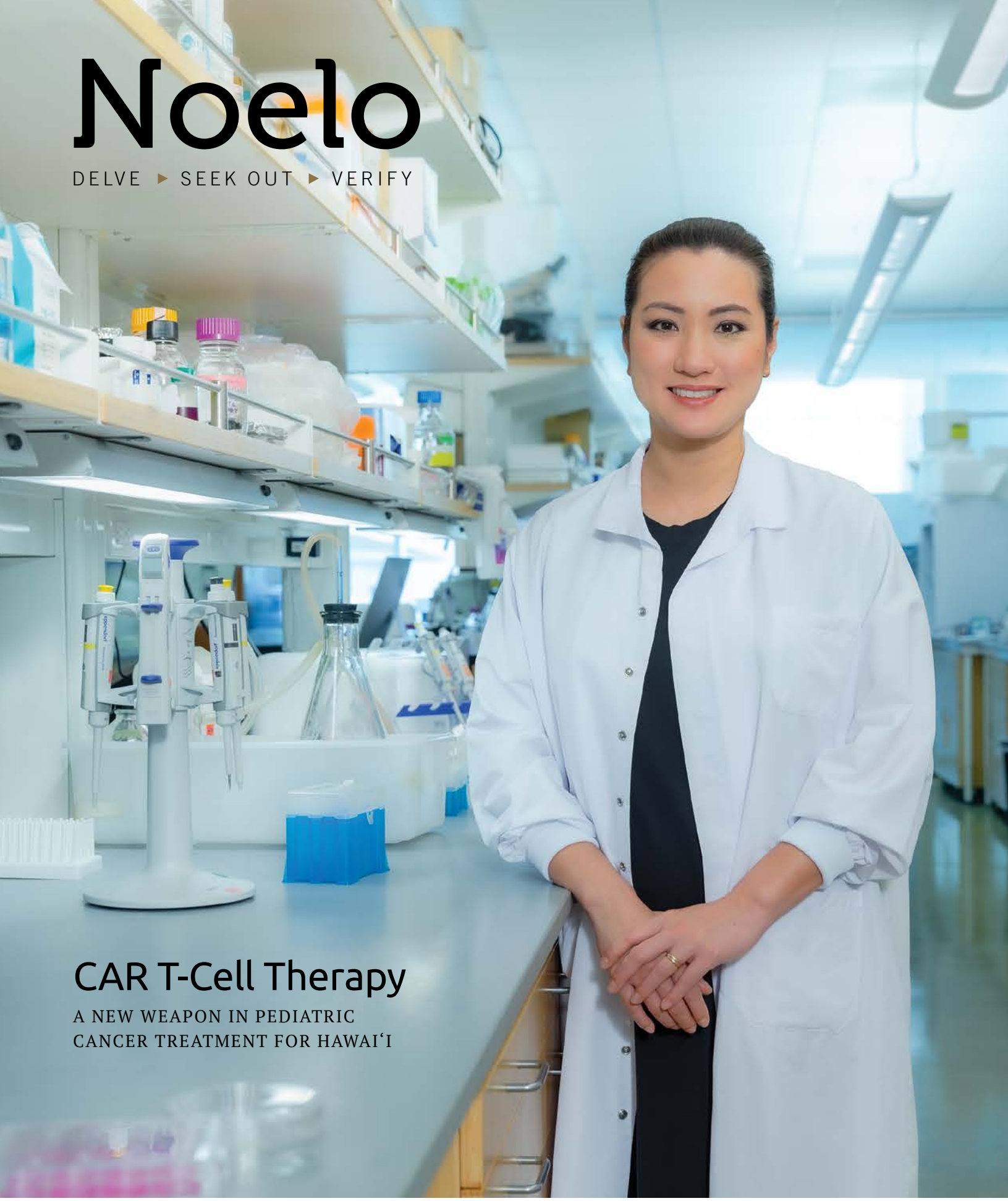
Noelo

DELVE ▸ SEEK OUT ▸ VERIFY



CAR T-Cell Therapy

A NEW WEAPON IN PEDIATRIC CANCER TREATMENT FOR HAWAIʻI

RESEARCH AND INNOVATION AT THE UNIVERSITY OF HAWAIʻI - 2022

UNIVERSITY of HAWAIʻI® SYSTEM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University of
Hawai‘i System

David Lassner, PhD
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*Vice President for
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***NOELO,* WHICH MEANS "TO DELVE, SEEK OUT OR VERIFY" IN HAWAIIAN, IS THE RESEARCH MAGAZINE OF THE UNIVERSITY OF HAWAI‘I SYSTEM PUBLISHED ANNUALLY BY THE OFFICE OF THE VICE PRESIDENT FOR RESEARCH AND INNOVATION.**

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In the face of global climate change, humankind's ability to rapidly adapt to sustainable and resilient practices will be vital to preserving our way of life and the life of the planet.

As the effects of climate change are being felt around the world, including severe drought, wildfires, coastal erosion, flooding and superstorms, these impacts are often significantly magnified on ocean islands with limited resources like Hawai‘i. Protecting our natural ecosystems and environment has become paramount to ensure that future generations can live, work and play here — and that is why the University of Hawai‘i (UH) recommitted itself to these efforts by renewing its sustainability and resilience initiative in 2019.

Whether conducting research on the frontlines, making an analysis in the laboratory or effecting policy changes, our multi-disciplinary cadre of researchers are actively engaged on a wide range of issues facing our community. Currently, UH researchers are on the ground assisting state, county and federal agencies on mitigation efforts relating to the fuel spill and subsequent aquifer contamination at the U.S. Navy's Red Hill Fuel Storage Facility on O‘ahu. Ongoing studies on Hawai‘i's unique hydrogeology by UH geologists to refine an earlier groundwater flow model, is helping to clarify the uncertainties surrounding the spill's effects on the aquifer.

While the state may have dodged the proverbial bullet on Red Hill, other constant threats remain to the health and well-being of our residents. The health disparities of Native Hawaiians, Pacific Islanders and Filipinos, who represent 40 percent of the state's population, have become a crisis. With the assistance of a $15 million grant from the National Institute of General Medical Sciences, the John A. Burns School of Medicine at the University of Hawai‘i at Manoa (UH Mānoa) launched a new center to build and sustain capacity in clinical and translational research to improve the health of these medically underserved groups.

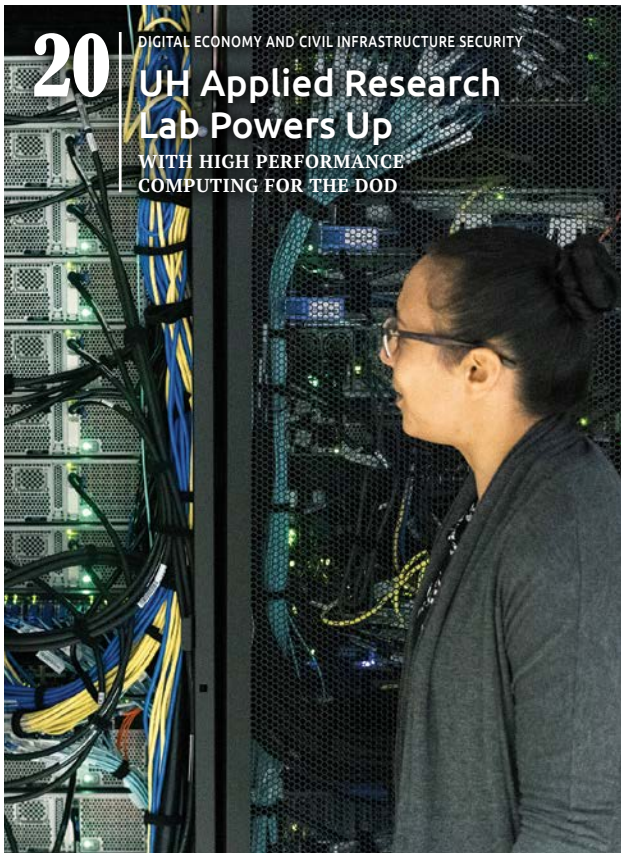
Although, we had hoped to put COVID-19 in our rearview mirror at this stage, the virus continues to affect our lives. Because of the importance of data is in this battle, we were fortunate to have the Hawai‘i Pandemic Applied Modeling work group on watch. This multi-organizational, multi-disciplinary team formed by UH Mānoa researchers during the height of the pandemic, provided valuable projections to the state and have helped to better prepare us for the future.

Find out more about these programs and other innovative bodies of work led by our world-class researchers on the following pages to see what makes the University of Hawai‘i — like no place on Earth.

Vassilis L. Syrmos, PhD
Vice President for Research and Innovation
University of Hawai‘i System

In This Issue

COVER: *Stephanie Si Lim MD in her research lab at the UH Cancer Center*



Exoplanets

THE HUNT FOR LIFE IN THE UNIVERSE

"ARE WE ALONE IN THE UNIVERSE?" is perhaps one of the most profound questions in the history of humanity. As early as the 16th century, philosophers such as Giordano Bruno hypothesized that the Universe may be filled with life, with thousands of Earth-like planets orbiting stars similar to the Sun in the Galaxy. However, it took several hundred years for such philosophies to be confronted with scientific evidence.

Over the past three decades alone, astronomers have discovered more than 5,000 planets orbiting stars outside the Solar System, known as exoplanets. The discovery and characterization of exoplanets is now one of the fastest moving and active fields in astronomy. One of the current leading instruments in exoplanet science is the NASA TESS space telescope, launched in 2018 to survey the nearest stars to the Sun for planets.

Dr. Daniel Huber, an astronomer at the University of Hawai'i at Mānoa's Institute for Astronomy (IfA), is one of several University of Hawai'i (UH) researchers who are heavily involved in the TESS mission. "One of the most fascinating aspects has been the vast diversity of planetary systems that have been discovered, most of which are completely unlike the Solar System," said Huber. "Some of this is because such planets are easier to find, but we also have examples of exoplanet systems that fundamentally challenge how our Solar System fits into context."

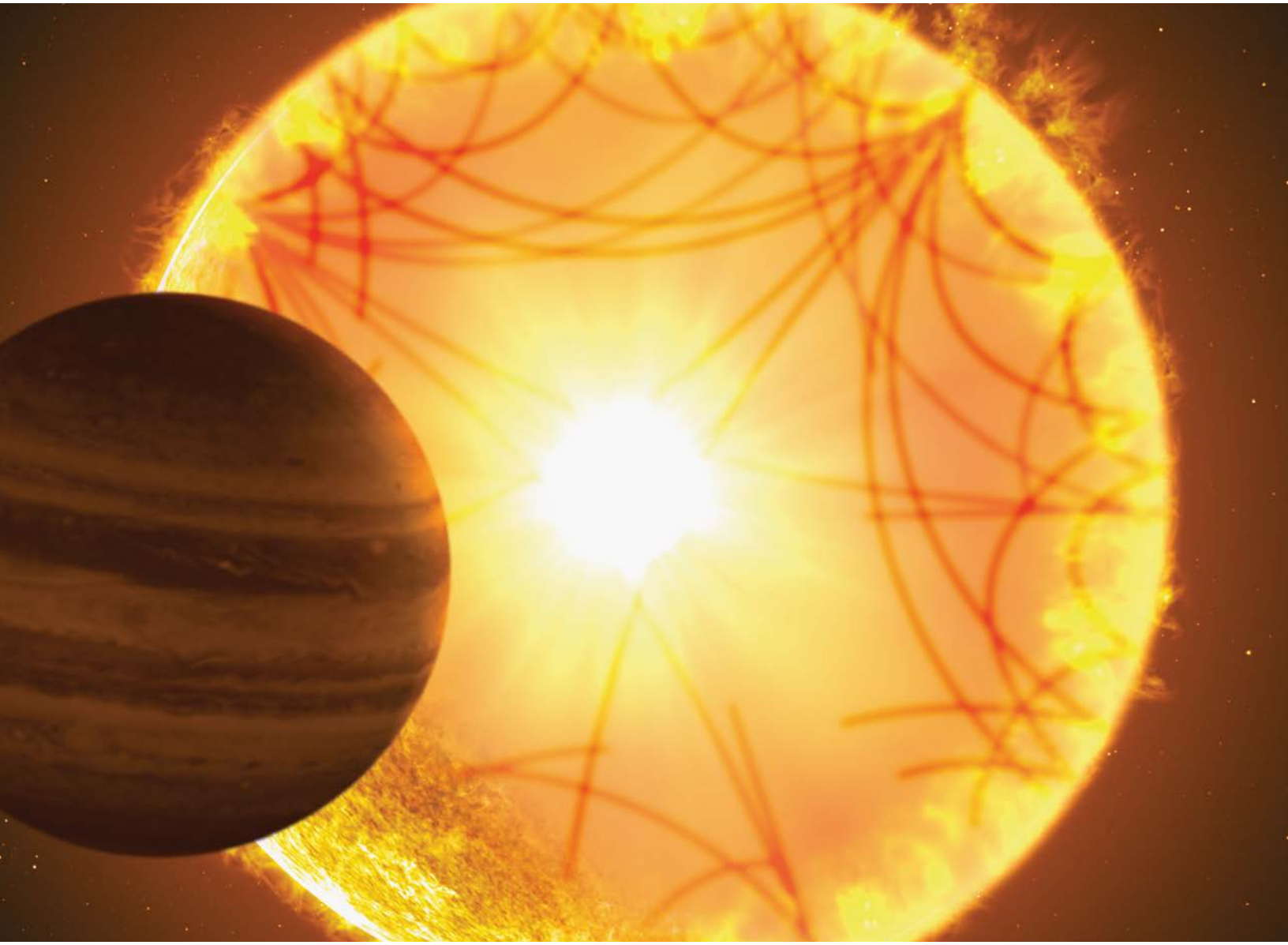
One such example was the discovery of one of the oldest known systems with Earth-sized planets in the Milky Way Galaxy, TOI-561b, enabled by TESS data and led by members of Huber's team. With an estimated age of 10 billion years, the discovery demonstrated that planets with sizes similar to Earth have formed for most of the history of the Milky Way Galaxy. Currently, the best estimate of the age of the Universe is 13.7 billion years, indicating that terrestrial planet formation has persisted for at least 70 percent of the history of the Universe.

"Systems such as TOI-561b help to start shaping our understanding of life in the Universe", said Huber. "On Earth, we know that the development of life took billions of years. While planets like TOI-561b are too hot for life to survive, examples like these give us indications that life has a long time to develop in other places in our galaxy."

Know Thy Star, Know Thy Planet

The majority of currently known exoplanets are discovered indirectly, detected either the gravitational pull of the planet on the host star (the "Doppler Wobble" technique, named after the Doppler effect) or a dip in the star's brightness caused by the fortuitous alignment between the star and planet (the transit technique). These approaches bring a challenge: most properties of planets are measured relative to the same properties of the star, and thus scientists' understanding of planets hinges on the precision of fundamental properties of stars. One of the powerful techniques to measure fundamental properties of stars is asteroseismology, which measures the frequencies of sound waves propagating through the stellar interior.

Artist's rendition of Kepler-1658b, a massive Jupiter-sized planet. Sounds waves propagating inside the star helped to confirm the planetary nature of the system.
CREDIT: GABRIEL PEREZ DIAZ/INSTITUTO DE ASTROFÍSICA DE CANARIAS



Over the past three decades alone, astronomers have discovered more than 5,000 planets orbiting stars outside the Solar System, known as exoplanets. The discovery and characterization of exoplanets is now one of the fastest moving and active fields in astronomy.

Daniel Huber, PhD CREDIT: IFA

"Think of the surface of a star as a boiling pot of water, but replace water with gas cells the size of the Earth that rise up, cool and sink down," said Huber. "This turbulence rings stars like a bell, and the resulting frequencies of waves that propagate through the star. The frequencies of these waves are directly related to basic properties such as size and structure, just as music instruments with different sizes have different natural pitches."

A similar process happens on Earth: seismic waves, caused by convection, make plates on the planet's surface move and bump up against one another, eventually leading to earthquakes.

Huber and his team exploit the power of asteroseismology to characterize stars and the planets they orbit. In 2019, a team led by a graduate student in Huber's group used this technique to confirm Kepler-1658b, a massive, Jupiter-sized planet orbiting its host star every four days. The planet is an example of the extreme diversity of exoplanets, and its existence provided strong constraints on the interior structure of the star itself, which dictates how quickly close-in planets can spiral into their host star.

In-depth Characterization from Maunakea

A key component in exoplanet science are observations using ground-based telescopes. In the case of transiting planets such as those discovered by the TESS mission, telescopes like those at the W.M. Keck Observatory on Maunakea on Hawai'i Island play a critical role in confirming candidate planets and adding additional information.

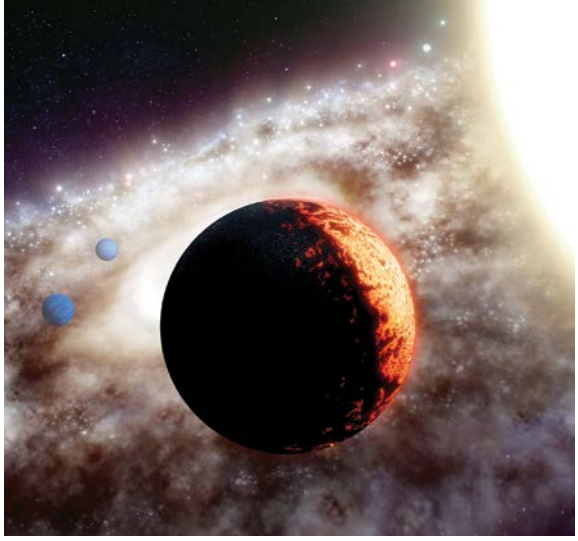
"The transit method gives us an estimate of the radius of the planet, which only tells us one part of the story," says Huber. "Ground-based observations such as those using the Keck telescope has provided planet masses, which give us a glimpse into what these planets may be made of. They are also critical to confirm that the planets suggested by the transit methods are actually real."

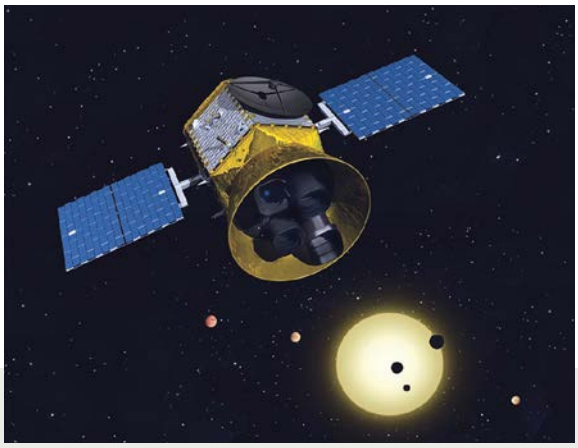
An example has been the recent confirmation of three transiting planets orbiting evolved "red giant" stars, which resemble a future version of the Solar System. These planets orbit so close to their stars that they will be engulfed within millions of years, a blink of an eye compared to the regular lifetimes of stars. Studying planets in such environments brings astronomers a glimpse as to what may happen to the Solar System planets as the Sun evolves over time.

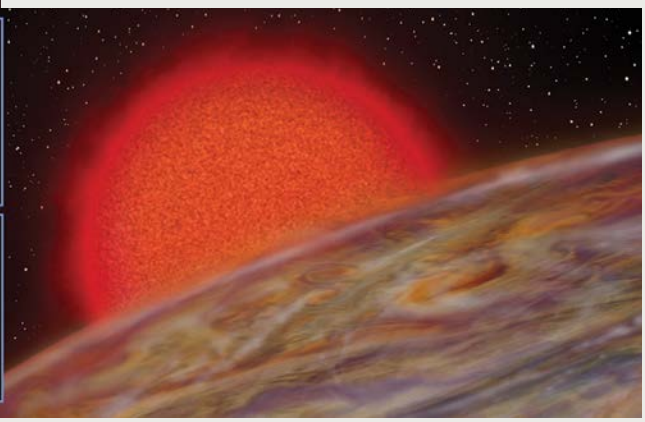
The Next Frontier: Earth-like Planets

The discovery and exploration of exoplanets has a bright future. Later this year, a science team including Huber will start first observations with the "Keck Planet Finder" (KPF), a next-generation instrument capable of detecting the Doppler Wobble of Earth-sized planets orbiting stars at distance in which liquid water can exist. Co-funded by UH, KPF will be the most efficient instrument of its kind and ring in a new era of ground-based exoplanet characterization.

At the same time, the astronomy community is making bold plans for next-generation







TOP: *Artist's rendition of TOI-561b, one of the oldest rocky planets discovered yet in the Milky Way galaxy.* CREDIT: W. M. KECK OBSERVATORY/ADAM MAKARENKO

MIDDLE, LEFT: *Artist's impression of NASA's Transiting Exoplanet Survey Satellite (TESS). UH researchers are using TESS data to discover and characterize planets orbiting stars outside the Solar System.* CREDIT: NASA

MIDDLE, RIGHT: *The W.M. Keck Observatory atop Maunakea on the Island of Hawai'i. With 10-m diameters, the two Keck telescopes are among the largest optical telescopes in the world and play a leading role in the study of planets outside the Solar System.* CREDIT: TBC

BOTTOM: *Artist's rendition of a planet orbiting a red giant star, a future version of the Sun* CREDIT: KAREN TERAMURA/IFA

telescopes to aid in the hunt for life in the Universe. The recently published Planetary Science and Astrobiology Decadal Survey 2023-2032 by the National Academy of Sciences gave top priority for next-generation ground-based telescopes, such as the Giant Magellan Telescope in Chile and the Thirty Meter Telescope in Hawai'i, which would enable astronomers to directly image planets that may harbor life and capture light that would allow them to probe their atmospheres for life. A next generation space-based flagship mission, expected to launch in the 2040s, will be optimized to allow the direct detection of true Earth analog planets around the closest stars.

"There is still much work to do, but I believe it is only a matter of time before we will find evidence for life outside the Solar System," says Huber, a recipient of the 2020 University of Hawai'i Regents' Medal for Excellence in Research. "And this will only be the first step in its interpretation. How old is the life we will find? Is it similar to life here on Earth?"

Astronomer Overcomes Hurdles to Inspire Others to Reach for the Stars

AS AN ELEMENTARY SCHOOL STUDENT growing up in Okinawa, Yuko Kakazu wanted to become a writer or novelist. However, when her middle school teacher recommended that she read a Japanese science magazine called *Newton,* it opened up an entirely different world for her. Kakazu became intrigued with the spectacular pictures of galaxies, nebulas, and solar systems, and was impressed with buzzwords like Einstein's Theory of Relativity. But, it was an ad in the magazine for NASA's Space Camp in Huntsville, Alabama that changed the trajectory of her career path when she half-jokingly asked her parents if she could attend—and to her surprise—they said yes.

Kakazu was fortunate to have parents and family that were very supportive of her, but she found that was not the case everywhere. She was often told by teachers that she was not good enough and that she could not compete with the students from the Japanese mainland. Despite the criticism and lack of encouragement, Kakazu earned her way into Japan's prestigious Tohoku University to study physics. But, she found more of the same there.

"My chemistry professor told me that women shouldn't study physics," said Kakazu. "I also saw my female chemistry classmates struggling because they were assigned projects that were not very interesting or challenging." Fortunately, Kakazu found a very different environment in physics with very supportive and fair professors.

In her junior year, Kakazu embarked on a student exchange scholarship program to the University of California, Santa Cruz (UCSC) and gained her first exposure to astronomy in Hawai'i through telescope observations using the W.M. Keck Observatory atop Maunakea on Hawai'i Island. The following year, she returned to Tohoku University and completed her Bachelor of Science degree in astrophysics and physics.

Impressed by her experience at UCSC and the wealth of opportunities for foreign students in this country, Kakazu decided to attend graduate school in the U.S. Because of the University of Hawai'i's unparalleled access to telescopes and abundant research opportunities, it became her number one choice. She was accepted to the University of Hawai'i at Mānoa's Institute for Astronomy and received both her master's degree and PhD from the world-renowned institute. Kakazu then embarked on a globetrotting research journey that took her to the Institut d'Astrophysique de Paris in France, the California Institute of Technology and the University of Chicago.

ABOVE: *Kakazu at NASA's Space Camp*

(Facing page)

LEFT: *Inside of NAOJ's Subaru Telescope on Maunakea*

TOP RIGHT: *Kakazu with third graders from Ernest Brown de Silva Elementary School in Hilo*

BOTTOM RIGHT: *Yuko Kakazu, PhD*

"In France, I was amazed to see so many women astrophysicists and that about 50 percent of the faculty there were women," said Kakazu. "People were very encouraging both in France and the U.S. so it made it easier to conduct my research."

As an observational astronomer, Kakazu's research focuses on galaxy formation and evolution, using a variety of instruments that provide multi-wavelength imaging and spectroscopic data that measure high redshift object movement of galaxies and their chemical composition. While the average layperson may have difficulty connecting her research and astronomy in general to everyday life, she feels it is quite the contrary.

"Astronomy is considered by many to be the oldest natural science, dating back thousands of years," said Kakazu. "To many ancient cultures, it has served an important role in terms of religion, timekeeping, crop planting calendars, navigation and other aspects of everyday life."

In 2013, she returned to Hawai'i to become the education and outreach specialist for the National Astronomical Observatory of Japan's Subaru Telescope on Maunakea. While working on a joint presentation with the 'Imiloa Astronomy Center at the University of Hawai'i at Hilo, the world's first contemporary science education center that promotes indigenous culture, Kakazu discovered similarities between Hawai'i and Okinawa in terms of culture and astronomy, that helped her to establish a connection with her own roots.

"In Okinawa, indigenous knowledge was used to create scientific instruments and develop calendars to determine the movements of the sun, moon and constellations to mark the changing seasons, some of which are still used today," said Kakazu, who admittedly was unaware of this because she was too immersed in her study of modern astronomy. "Similarly, the early Polynesians used the stars to navigate thousands of miles of ocean to reach Hawai'i and other parts in the Pacific. They were all amazing scientists."

Building upon what she has learned, Kakazu is currently engaged in an educational program that seeks to create awareness and access to STEM, while developing a cross-cultural relationship between underserved and underrepresented students in Okinawa and Hawai'i. Known as SHIMA (Japanese for island), the program was launched last year by the Okinawa Institute of Science and Technology (OIST) featuring sustainability and marine sciences as topics. With this year's program focusing on sky, space and land, Kakazu is preparing the astronomy segment.

"Unfortunately, poverty and a lack of access to educational opportunities remain major issues in Okinawa and to underrepresented populations here in Hawai'i," said Kakazu. "However, through outreach programs like this and others, we can show students that there is a career path, and let them know it's possible for them to become a scientists."

Kakazu first began her association with OIST in 2014 by serving as a guest speaker at a number of events, including gender summits and STEM workshops for students. In 2019, she became a trustee of the OIST Foundation and was named its education ambassador in 2021. She hopes to make OIST an international hub of student exchange programs focused on science, indigenous knowledge and culture.

"Without my education, I wouldn't have been able to come this far," said Kakazu. "While growing up in Okinawa, I never saw a scientist or even knew I could become one. However, because of my parents' belief in me, I was able to become the first woman in my family to earn bachelor's, master's and PhD degrees."

She has the same belief for all students.

CAR T-Cell Therapy

A NEW WEAPON IN PEDIATRIC CANCER TREATMENT FOR HAWAIʻI

CHEMOTHERAPY, SURGERY, AND RADIATION HAVE BEEN THE MAIN PILLARS of cancer treatment for many decades. While they remain at the forefront against the war on cancer, new categories of treatments have emerged over the years that have revolutionized the scope and effectiveness of cancer therapy, while lessening or eliminating some of the commonly associated side effects.

Over the past decade, immunotherapy, which utilizes the patient's own immune system to attack cancer cells, has picked up considerable momentum and is quickly becoming recognized as a fourth pillar of cancer treatment. Of these immunotherapy treatments, chimeric antigen receptor T-cell (CAR T-cell) therapy, has garnered the attention of researchers and oncologists around the world, especially for treating certain cancers in children that are no longer responding to standard treatments.

One of the staunch advocates of CAR T-cell therapy is University of Hawaiʻi Cancer Center (UH Cancer Center) Researcher Stephanie Si Lim, MD, a pediatric oncologist who has been instrumental in bringing this promising new cancer treatment to Hawaiʻi.

As a youngster growing up on Hong Kong, Si Lim always knew that her love for children that blossomed from an early age would determine her career path, either as a teacher or a pediatrician. Eventually, through her biological sciences classes and volunteer work in a pediatric oncology ward during high school, Si Lim developed a keen interest in human physiology and anatomy, which ultimately led her to choose medicine as her career. That passion and drive would eventually lead her to obtaining a Bachelor of Science degree in biology from Pepperdine University, a medical degree from the Georgetown University School of Medicine and a prestigious residency and fellowship training in pediatric hematology/oncology at the Children's Hospital of Philadelphia (CHOP), an internationally recognized leader in advanced pediatric medicine.

While at CHOP, Si Lim trained under noted pediatric oncologist Stephan Grupp, MD, who treated the first ever pediatric patient with relapsed/refractory B cell acute lymphoblastic leukemia (B-ALL) with CAR T-cell therapy. This groundbreaking clinical trial eventually led to the first and only FDA approved product for children and young adults with B-ALL, the most common cancer found in this age group.

"I was fortunate to be mentored by some of the leading pioneers and world-class experts in CAR T-cell therapy, and witnessed firsthand what a life-saving therapy this could be," said Si Lim. "That's what inspired me to bring this cutting-edge therapy to Hawaiʻi, so that our community can also have access to this treatment without having to travel to the mainland for long periods of time."

According to Si Lim, the body's immune system usually works by detecting foreign substances, known as antigens, on the cell surface. Immune cells such as T-cells contain specific receptors that attach to these antigens and trigger the body's immune response to destroy the foreign substance. Cancer cells also have antigens, but if the immune cells are overwhelmed and cannot effectively recognize such antigens, then they fail to do their job to clear out the cancer cells.

In CAR T-cell therapy, T-cells are collected from the patient's blood and modified in the laboratory to introduce an engineered receptor, known as a chimeric antigen receptor or CAR, that will allow the T-cell to bind with the specific cancer cell antigen. The CAR T-cells are then grown, multiplied to sufficient quantities through a process that takes several weeks and are then infused back into the patient.

"CAR T-cell is a very novel therapy for cancer as it can target specific antigens to selectively remove and kill the tumorous cells, while sparing the non-affected healthy cells," said Si Lim. "As a result, unwanted side effects like hair loss, nausea or mouth sores from traditional chemotherapy or radiation treatments are minimized or eliminated."

In addition to her role at the UH Cancer Center, Si Lim is also a faculty member at the University of Hawaiʻi at Mānoa's John A. Burns School of Medicine and has a clinical practice in pediatric oncology at the Kapiolani Medical Center for Women and Children, one of four medical centers under Hawaiʻi Pacific Health (HPH), and one of Hawaiʻi's largest healthcare providers. As Physician Leader for HPH's Cellular Immunotherapy Program, in June 2022, Si Lim orchestrated a joint initiative between HPH

LEFT: *Stephanie Si Lim, MD and team members Chakkapong Burudpakdee and Jannes Steinmann isolate peripheral blood mononuclear cells for flow cytometry, which allows them to profile immune cells on a single cell level*

MIDDLE: *Si Lim consults with one of her patients*

RIGHT: *University of Hawai'i Cancer Center*

and the UH Cancer Center to bring CAR T-cell treatment and clinical trials to Hawai'i.

"Stephanie has been a tremendous addition to our staff of world-class cancer researchers at the UH Cancer Center," said Joe W. Ramos, former interim director of the UH Cancer Center. "Through her extensive experience and training in CAR T-cell therapy, Stephanie is not only bringing a new level of cancer care to pediatric patients in Hawai'i, but is also bringing important clinical trials that will benefit from our state's multiethnicity — a strength of the UH Cancer Center."

While there still remain many unanswered questions in pediatric oncology, Si Lim's current research focus is on ethnic disparities in adoptive cellular immunotherapy, specifically in CAR T-cells. She hopes to better understand if race and ethnicity play a part in patient outcomes when receiving CAR T-cell therapy, as current trials have not addressed this factor.

"Hawai'i has a very unique demographic known as a minority-majority population, where Asians and other underrepresented populations are the majority," said Si Lim. "With the results from our clinical trials, we will be able to compare our patient outcomes with the outcomes for patients on the mainland, where there is a 70 to 80 percent representation of Caucasians — enabling us to get a more accurate picture of the therapy's effectiveness in a more diverse population."

The introduction of CAR T-cell therapy to Hawai'i also improves access to the cutting-edge therapy for underserved populations, including Native Hawaiians, Pacific Islanders and residents on the Neighbor Islands that previously was close to impossible — requiring travel to the mainland for treatment in places like Seattle or San Francisco, separation from family and friends for more than three months and the incurrence of huge travel and lodging expenses.

"Imagine being in a foreign place with a very sick child whose outcome is unknown and without your family support group — that's insane!" said Si Lim. "Now patients can feel more at ease by being home with their family members and close support network, and have a better chance of recovery, since we often find that the emotional support is just as important as their medical care."

For Si Lim, it has always been about the children. While there have been some losses, they serve as further motivation to find out why a patient didn't respond to therapy and what can be done better in the medical and scientific community to help more children survive.

"I think pediatric oncology itself is a beautiful field, comprising of being both a primary care and an acute care physician," said Si Lim. "In addition to taking care of the patient, I get to form a lasting relationship with the family for the duration of when they're with me and become a part of their support system — which I think is very special and rewarding."

PIKO

IMPROVING HEALTH EQUITY

HAWAIʻI'S DESIGNATION AS ONE OF THE "HEALTHIEST" STATES IN THE NATION belies shocking health disparities among Native Hawaiians, Pacific Islanders, Filipinos and other medically underserved populations.

While Native Hawaiians, Pacific Islanders, and Filipinos collectively account for 40 percent of the state's population, they remain medically vulnerable, with disproportionately higher rates of physical ailments and mental health conditions, shorter life spans, and poorer access to healthcare, than Caucasian and Asian people in Hawaiʻi.

"Left unaddressed, the health gaps between these three groups — Native Hawaiians, Pacific Islanders, and Filipinos — and other groups in Hawaiʻi will likely widen, placing a greater burden on these communities and a state budget that is already struggling with major socioeconomic challenges, especially with the recent economic downturn from the COVID-19 pandemic," said Joseph Keaweʻaimoku Kaholokula, PhD, professor and chair of the Department of Native Hawaiian Health at the John A. Burns School of Medicine (JABSOM).

"With the highest population of Indigenous Pacific People in the U.S., Hawaiʻi is the perfect place to conduct research to develop solutions that will impact and benefit both the local and global indigenous communities," added Neal A. Palafox, MD, MPH, professor at JABSOM's Department of Family Medicine and Community Health.

A Community-Based Approach

In response, JABSOM launched a new Center for Pacific Innovations, Knowledge, and Opportunities (PIKO) to work toward improving the health and wellbeing of Native Hawaiians, Pacific Islanders, Filipinos and other medically underserved populations in Hawaiʻi.

Taking a team-science approach, PIKO is developing new and leveraging existing resources across its partnering institutions, which include the UH System, Hawaiʻi Pacific University (HPU), Chaminade University of Honolulu (CUH) and a statewide network of 18 practice-based organizations (PBO) and other community-based organizations (CBO).

"This is an unprecedented initiative in Hawaiʻi that is bringing together academia, non-profit, government and healthcare partners and stakeholders across Hawaiʻi to support efforts consistent with state and federal policies, and call for culturally responsive healthcare solutions and a stronger, more diversified workforce," said Kaholokula, one of PIKO's principal investigators.

While UH has succeeded in competing for and conducting research for basic scientific discoveries and early-phase clinical trials, there have been few opportunities to build and sustain capacity for research on the later end of the clinical and translational research (CTR) continuum, such as community-based efficacy, effectiveness trials and research that addresses the social determinants of health — research with immediate, real-world impact.

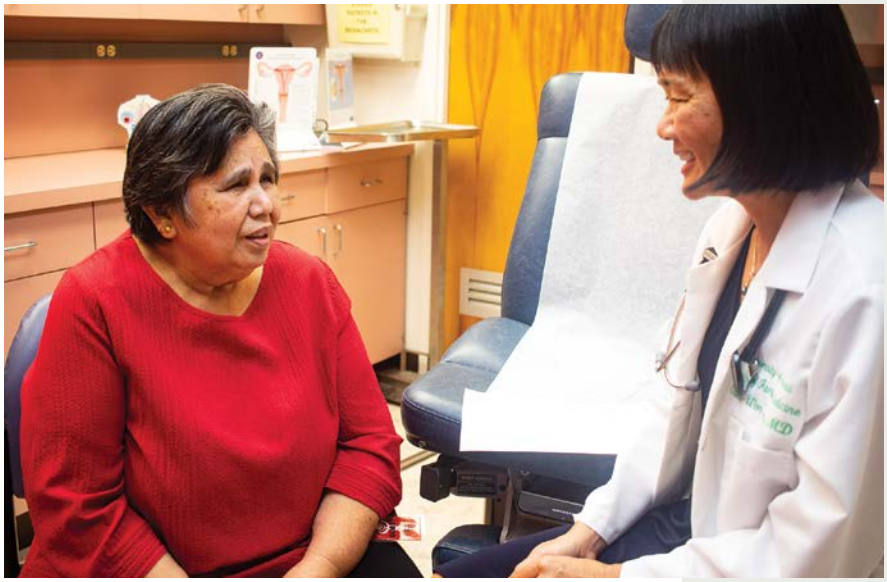
Through a five-year, $15-million Institutional Development Award (IDeA) grant from the National Institute of General Medical Sciences (NIGMS), PIKO is building a robust infrastructure and strategies to support more advanced CTR initiatives and the dissemination and implementation of innovations leading to improved health, as well as healthcare solutions, across partnering institutions and communities who need them the most.

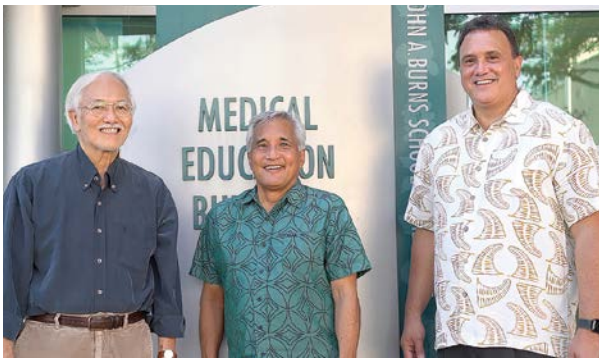
However, in order to effectively identify the root causes of poor health and disparities among Native Hawaiians, Pacific Islanders, Filipinos and other underserved groups, and to develop culturally responsive and impactful interventions, PIKO is also addressing the lack of representation from these communities as both CTR participants and CTR investigators.

UH Investment in CTR and Growing the CTR Workforce

To further support growing and diversifying the CTR workforce, UH Mānoa has also committed $1.3 million over five years to help PIKO accomplish its CTR and workforce goals to increase the number of new and early-stage CTR investigators from Native Hawaiian, Pacific Islander and Filipino communities.

"Achieving health equity in Hawaiʻi's marginalized populations requires dedicated and sustained investments in relevant discovery and problem-solving tasks that belong to the people of these communities, and will help us transform our current health-promotion and disease-prevention paradigms," said Palafox,





also a PIKO principal investigator.

PIKO Core initiatives include: Professional Development; Pilot Projects Program; Biostatistics, Epidemiology, and Research Design; Community Engagement and Outreach; Clinical Research and Regulatory Support; Tracking and Evaluation, which ensures PIKO is meeting its milestones and objectives; and Administrative, which oversees and facilitates CTR infrastructure building.

Within the first ten months, PIKO has provided an intensive, six-month grant writing training workshop to ten junior and mid-level faculty from across the UH System through its Professional Development Core, with support from the Biostatistics, Epidemiology, and Research Design Core.

Through the Clinical Research and Regulatory Support Core, PIKO also joined two National Institutes of Health (NIH)-supported national research projects — Researching COVID to Enhance Recovery (RECOVER) and National COVID Cohort Collaborative (N3C) — to better understand the medical impact of COVID-19 on our communities. In April 2022, PIKO organized its first annual Capacity Building Workshop through its Community Engagement and Outreach Core. The event gathered PIKO-supported researchers, mentors, and community partners, as well as leading experts in indigenous and community health, data science, and community-engaged research, to share best practices and lessons learned.

In addition, PIKO launched its Pilot Projects Program, awarding $50,000 each to seven new and early-stage investigators from UH Mānoa, UH West O'ahu, UH Hilo and HPU to conduct culturally responsive and scientifically meritorious CTR projects. The 12-month projects include identifying the impact of socio-economic and geographic factors; understanding resilience and 'Āina-connectedness; reducing adverse pregnancy outcomes; and developing specific treatments for mosquito-borne flaviviruses.

"We are excited to support emerging researchers in their efforts to conduct and accelerate the pace of research that is responsive to the health needs of our communities," said Richard Yanagihara, MD, MPH, who serves as PIKO's program director. "The purpose of this program is to help us address real-world challenges and to design community-responsive solutions that will reduce health disparities and advance health equity throughout the state."

For more information about PIKO, visit piko.jabsom.hawaii.edu/.

PIKO
CENTER FOR PACIFIC INNOVATIONS, KNOWLEDGE AND OPPORTUNITIES

ABOVE: *PIKO Program Director Richard Yanagihara, MD, MPH; and Principal Investigators Neal Palafox, MD, MPH and Joseph Keawe'aimoku Kaholokua, PhD*

Paradigm Shift

UH SHEDS NEW LIGHT ON HAWAIʻI'S GROUNDWATER FLOW

THE RECENT CONTAMINATION of the Red Hill Shaft well due to leaked jet fuel from the U.S. Navy's Red Hill Bulk Fuel Storage Facility on the Island of Oʻahu severely impacted the daily lives of the families, schools, businesses and communities reliant on this major Honolulu aquifer. Although extensive mitigation efforts are still underway at the World War II-era underground facility that holds more than 100 million gallons of fuel just over 100 feet from the aquifer, Oʻahu residents were fortunate to be mostly spared from a potentially devastating water crisis.

"The spill at Red Hill resulted in a renewed appreciation by residents of how important the availability of a safe drinking water source is to an island that is located 2,390 miles from the closest continent," said Don Thomas, senior researcher and co-founder of the Hawaiʻi Groundwater & Geothermal Research Center (HGGRC) at the University of Hawaiʻi at Mānoa (UH Mānoa). "Of equal importance, the event forced Hawaiʻi's policy-makers and regulatory agencies to recognize that managing and protecting the quality and the sustainability of the state's groundwater resources is far more complex and difficult than previously understood."

According to Thomas, a geochemist who represents the University of Hawaiʻi (UH) on a panel of experts formed by the regulatory agencies to oversee the U.S. Navy's work, a significant disconnect in the situation at Red Hill has been a standing conflict between the groundwater flow model developed by the U.S. Navy's contractors and an independent evaluation by a team of experts assisting the regulatory agencies that used a broad range of updated groundwater data, including chemistry, temperature and water levels. The U.S. Navy based their conclusions on a groundwater flow model that was developed more than eight decades ago.

The Traditional Model

The traditional model was a monumental body of work developed by noted geologists Herald Stearns, Gordon Macdonald, Chester Wentworth and Knute Vaksvik that the Territory of Hawaiʻi published as a set of reports on the geology and groundwater resources of each of the main islands. It was based on the measurements and observations of many exploratory and production wells, and describes how rainfall infiltrates the ground and recharges fresh water aquifers that tend to accumulate within ocean islands. Over time, that fresh water recharge migrates toward the shoreline where it is discharged through coastal springs and near-shore submarine groundwater discharge. In regions of higher rainfall, more fresh water accumulates and can displace salt water downward to form a progressively thicker "lens" of fresh water saturated rocks that rest atop salt water saturated rocks below. It served as a benchmark on how Hawaiʻi's groundwater is stored inside the island and flows to the ocean. (See https://scholarspace.manoa.hawaii.edu/handle/10125/50758.)

However, as decades have passed, new techniques and more recent investigations have gathered an increasing body of data that indicate the traditional model does not tell the entire story. Prior to his retirement from UH Mānoa in the mid-1970s, Macdonald explained in a presentation that their model was still incomplete. According to measurements, there was more water infiltrating the islands than they could find being discharged along the shoreline. Something was clearly missing from their equation since input had to balance output. Either their estimates of the volume of groundwater recharge were incorrect, or their method of estimating shoreline discharge was flawed.

Evidence Toward a New Model

Interestingly, one of the first research projects that cast doubt on the traditional model was one that was led by Macdonald himself — the drilling of a deep research borehole in Lower Puna, on Hawaiʻi Island, to investigate the potential for geothermal resources. Because the well extended more than a mile below sea level, the scientific team expected it to produce geothermal fluids derived from seawater, but they were surprised to find that the salt content of the production liquid was equivalent to only approximately 10 percent of seawater. Drilled in an unusual geologic environment known as a "dike complex" in the Kīlauea East Rift Zone, the absence of salt water coming from the surrounding ocean was due to dense, impermeable dike rocks.

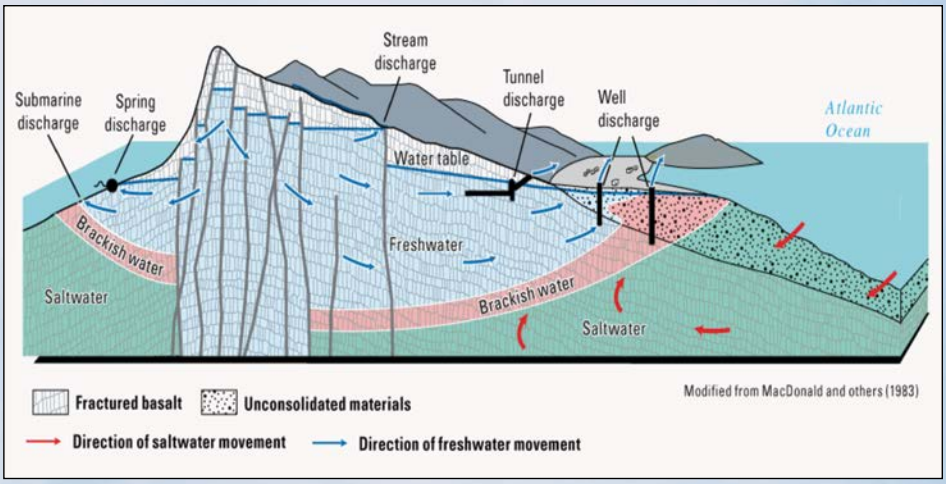
However, another deep well located just north in the town of Hilo provided results that were less simple to explain. The project was

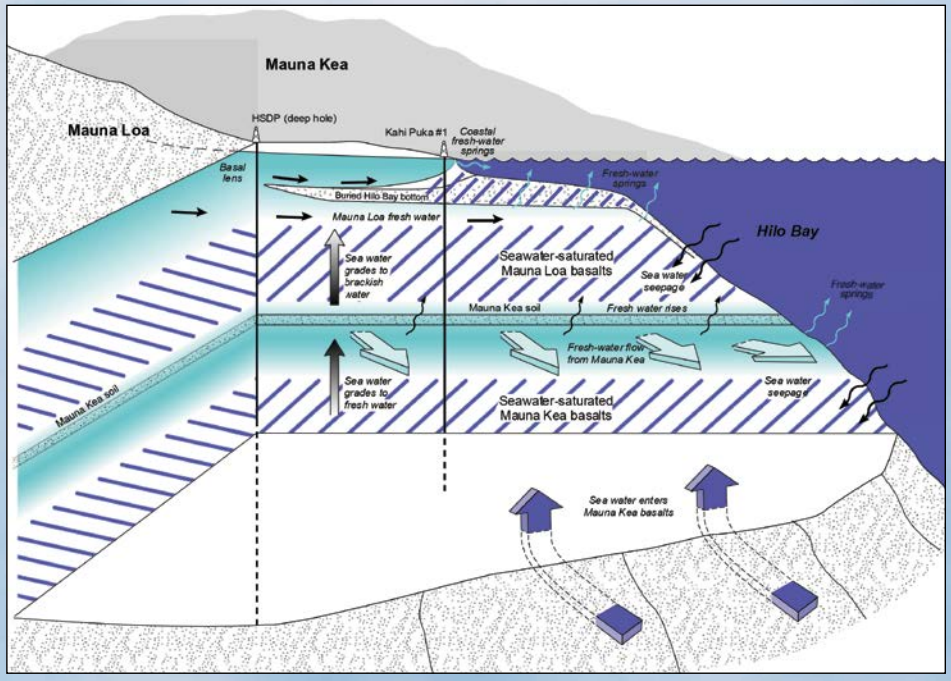
(CONTINUED ON PAGE 16)

TOP: The traditional model of Hawai'i's groundwater taken from Macdonald, Abbett, and Perterson, *Volcanoes in the Sea: The Geology of Hawaii*

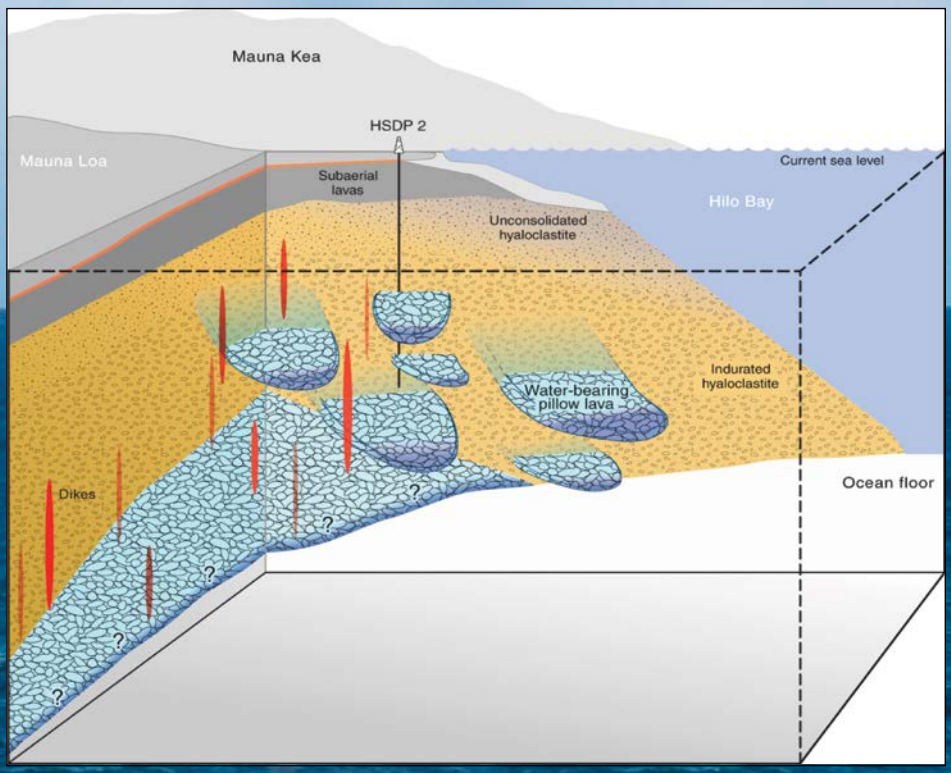
MIDDLE: A conceptual model of groundwater below Hilo — this is the first, shallow artesian zone

BOTTOM: A conceptual model of the deeper freshwater saturated zones starting at 6,500' below ground surface extending to 10,000' below ground surface





ABOVE: *Artesian water coming to the surface while drilling the HSDP hole in Hilo.*



LEFT: *Image of rocks recovered from one the HSDP wells that showed the dense impermeable formations that were confining the groundwater into pressurized aquifers*

sponsored by the National Science Foundation (NSF) and named the Hawai'i Scientific Drilling Project (HSDP). HSDP studied the evolution of a Hawaiian Hotspot (or mantle-plume) by collecting a nearly continuous sequence of lava flow samples from the ground surface to a depth of 11,540 feet. Researchers expected to drill through a few hundred feet of shallow rocks saturated with fresh water at most, and then into salt water saturated rocks that would continue to the entire depth of the hole. The team drilled through the shallow fresh water lens into salt water at a few hundred feet below the surface, but at about 1,000 feet below sea level, a second fresh water layer was encountered that was determined to have come from rainfall entering the island at an elevation of approximately 7,000 feet above sea level over 2,000 years ago. That water was also unexpectedly artesian and rose to the surface at a rate of more than 2,000 gallons per minute. As drilling continued, layers of fresh water saturated rocks were found down to a depth of more than 10,000 feet below sea level. That water was too old to date using conventional methods, but had a composition that allowed researchers to estimate that it had been in contact with the deep basalts for approximately 100,000 years or longer. There was no rift zone near this location and the findings clearly demonstrated that the conventional model for how groundwater was moving inside the Hawaiian Islands needed an update.

"The presence of that deep fresh water also told us something very important: in order for water to get to such great depths into the island, it must displace more dense salt water, but that could only occur if elevation of the fresh water, known as the 'fresh water head,' was much higher inside the island than the traditional model had assumed," said Thomas. "The traditional model argued that, at most, the elevation of the groundwater table would be only 100 to 200 feet above sea level."

To test the hypothesis that the water table was much higher, UH researchers joined up with geophysicists from the United States Geological Survey to employ geophysical methods to measure the electrical resistivity of the rocks deep inside of the Humu'ula Saddle that extends between Maunakea and Mauna Loa. Those measurements indicated that, over parts of the Saddle, very resistive (dry) rocks extend to depths of only several hundred feet below the surface. Below this to a few hundred feet above sea level, the resistivity is consistent with fresh water saturated rocks, and below that, the resistivity dropped by 95 percent to that of fresh water saturated rocks due to thermal activity.

Two additional wells were drilled higher on the island and the team discovered aquifers that reached an elevation of approximately 4,600 feet above sea level. This elevation of groundwater would provide enough hydrostatic pressure to allow fresh water to the depths first observed in the HSDP well, and is more than sufficient to allow fresh water to displace seawater to the underlying sea floor beneath the island. Tests also indicated that rather than a continuous body of freely mixing groundwater inside the island, different layers of soil and ash form impermeable barriers to the free flow of water and form what are called confined aquifers. In one of the confined aquifers, researchers found that the water pressure below the confining layer was able to send water to an elevation of more than 3,500 feet above the aquifer depth.

Importance of the New Findings

Recently, UH conducted more detailed investigations of the groundwater on the west side of Hawai'i Island, where water is scarce. That research, funded by 'Ike Wai, an NSF-funded Established Program to Stimulate Competitive Research (EPSCoR) project, revealed that similar confined aquifers are present on the flanks of Hualālai Volcano, where recent wells have also encountered a similar sequence of fresh—salt—fresh layering. Geophysical surveys conducted offshore showed that those aquifers extend out into the submarine flanks of Hualālai and represent a very large, previously unrecognized reservoir of fresh water. These deep fresh water aquifers have water that is of higher quality than the previously developed basal groundwater system, and which can be accessed at a much lower elevation than wells further inland.

Despite these encouraging discoveries, Thomas cautions that more work needs to be done to understand how the deep fresh water system responds to water withdrawal, and the potential environmental implications of its use. However, these discoveries open up the possibility that wells which pull water from the basal aquifer and consume huge amounts of energy can be shut down, resulting in the restoration of the natural flow of shallow groundwater discharge and the reintroduction of essential nutrients to the near-shore ecosystem.

"Some of these same features, confined saturated layers with groundwater elevations well above where they are expected to be, can be observed in the data produced by the U.S. Navy contractors' work in the vicinity of the Red Hill facility," said Thomas. "That clearly indicates that we cannot just assume that groundwater will follow the paths prescribed by our traditional model for Hawai'i's groundwater flow."

In response, UH has requested funding from the Office of Naval Research to conduct extensive geophysical work, as well as a detailed analysis of the geology, and groundwater chemistry, to develop a conceptual model for groundwater flow at Red Hill that is consistent with both large-scale and small-scale geologic features. Features that researchers now understand have a much greater influence over groundwater and contaminant transport than is possible with the existing U.S. Navy model.

"Once we have completed work related to the Red Hill fuel contamination, it is our intention to expand our efforts island-wide to better understand O'ahu's groundwater resource, then extend these studies to the other islands," said Thomas.

"We hope that a better understanding of our groundwater will lead to better protection and management of these irreplaceable resources."

Water is Life

UH MĀNOA'S WATER RESOURCES RESEARCH CENTER

IN THE MID-1950S, much of America's focus was toward the sky, as the United States engaged in a space race with the Soviet Union. Powerful rockets, satellites and astronauts in orbit captured much of the attention in the headlines and in research.

However, back on Earth, a less visible, but arguably more important need was arising — to preserve America's freshwater resources from growing problems arising from human development and overpopulation, natural disasters, and to a lesser degree at that time — climate change. One would have been hard-pressed to find any comprehensive findings on the matter, as echoed by the late Hawai'i Representative Tom P. Gill in his address to Congress in 1964.

"Our rapidly rising population, falling water tables, increased pollution of existing supplies, and tremendous new uses for water all combine to make knowledge of this life source more critical each day," he said. "Strangely, we have long taken water for granted; our scientific effort and our funding of knowledge in this commonplace subject has been minimal, compared to advances in more spectacular areas."

At the urging of Congress, President Lyndon B. Johnson signed into law the Water Resources Research Act (WRRA) of 1964 that led to the creation of 54 research centers hosted by land-grant universities in each state, Washington D.C., Guam, Puerto Rico, and the U.S. Virgin Islands — including the Water Resources Research Center (WRRC) at the University of Hawai'i at Mānoa (UH Mānoa).

"For Hawai'i, like other oceanic islands, any problem that limits availability of freshwater is magnified because of isolation and limited land area," said Thomas Giambelluca, director of the UH Mānoa WRRC.

"As a result, Hawai'i is very vulnerable to changes in water supply brought about by climate variations and especially by climate change. Against a backdrop of limited water supply and growing water needs, a water contamination event that leads to the closing of major drinking water wells can lead to a major water supply crisis. As such, the work of WRRC is vital to Hawai'i, American Samoa, and other islands across the Pacific."

Led by nine faculty researchers — most of whom are joint appointees active in such related fields as civil and environmental engineering, geography and environment, earth sciences, and microbiology — WRRC promotes cooperation among academic disciplines concerned with water issues and facilitates the transfer of research results to policy making bodies and operational agencies.

Over the years, WRRC researchers have worked on the most pressing water-related issues of the day, while also often contributing to the advancement of water science as it pertains to tropical islands globally. While new issues of concern have emerged since the mid-1960s, fundamental themes have been maintained in groundwater modeling; measurement and modeling of groundwater contaminants; hydrogeological investigations; estimation of groundwater recharge, streamflow and flooding; meteorological processes; watershed management and protection; agricultural and urban water use; irrigation management; wastewater treatment and disposal; impacts of cesspool polution and alternative onsite wastewater disposal technologies; coastal water quality; water allocation; and water rights.

"Much of our emphasis has shifted to include more work on the impacts of climate change; societal values and water; indigenous, especially Native Hawaiian approaches to water management; and issues of equity and justice in the distribution of the benefits of water-related ecosystem services," added Giambelluca, who is also a professor in the Geography and Environmental Department at UH Mānoa.

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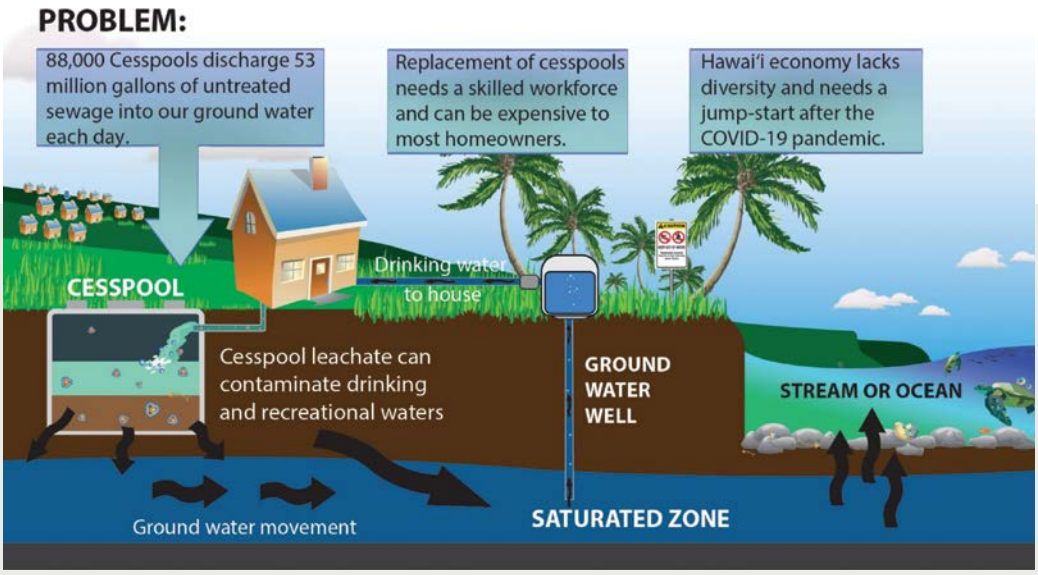


LEFT: *An illustration of problems caused by cesspools to groundwater, streams and oceans in Hawai'i*

Researchers at WRRC have two well-equipped, state-of-the-art laboratories at their disposal to run comprehensive tests on their field samples. The Analytical Laboratory is equipped with a wide variety of instruments to detect environmental pollutants at trace levels of parts per million (ppm), parts per billion (ppb) and parts per trillion (ppt). Pollutants range from volatile and semi-volatile organic compounds such as petroleum hydrocarbons, industrial solvents, explosives, pharmaceuticals to endocrine disruptors such as organochlorine pesticides, polychlorinated biphenyls (PCBs) and poly nuclear aromatic hydrocarbons (PAHs). In addition, the laboratory features instruments that can perform measurements for major ion, total organic carbon, total nitrogen, surface area, zeta potential and metals. The Environmental Microbiology Laboratory contains a real-time polymerase chain reaction (PCR) thermal cycler to amplify segments of DNA, electrophoresis equipment for DNA and RNA analysis; four Portable Multiuse Automated Concentration Systems (PMACS) to capture the smallest virus from large water samples; and epiflorescent and inverted microscopes to view microorganisms.

Current Projects

"WRRC continues to address problems related to Hawai'i's precious water resources as they are impacted by climate change, invasive species, increases in human population, expanding urban development, and a variety of sources of microbial and chemical water contamination," said Giambelluca.

"Chief among those problems are climate warming (increasing water demand) and attendant shifts in rainfall (decreasing water supply in some areas), the spread of high-water-use invasive plants, cesspool pollution, and chemical contamination of groundwater—including the recent contamination of drinking water wells and distribution systems resulting from jet fuel leaks at the U.S.Navy's Red Hill underground fuel storage tank facility."

Red Hill Bulk Fuel Storage Facility

The Red Hill crisis has become a primary concern of WRRC since news broke in early December 2021 and it has taken the lead in coordinating the University of Hawai'i's Red Hill Task Force, comprised of 68 individuals from the UH System with a wide range of expertise related to the contamination event. Task Force members are working with state, county, and federal agencies to identfy and address research needs, collect water samples, conduct laboratory testing of water samples, develop methods for continuous monitoring of groundwater for contaminants derived from the fuel leak, survey residents of the affected communities, and assess and mitigate looming water shortages resulting from well closures. Currently, WRRC is seeking funding from the Department of Defense to upgrade its analytical chemistry laboratory equipment and staffing to further enhance its support of the Task Force.

Cesspool Replacement

Hawai'i has around 90,000 cesspools in operation. These outdated systems are the source of millions of gallons of raw sewage flowing every day into our groundwater, streams, and coastal waters. In 2017, Hawai'i became the last state in the U.S. to mandate the replacement of cesspools with more effective alternative onsite disposal systems. Despite having a deadline of 2050, the law does not provide a pathway for developing local expertise, permitting capacity, a construction labor force, or mechanisms to help homeowners pay for the costs. In response, WRRC, and the Hawai'i Sea Grant Program are participating in the Work-4-Water initiative, led by the non-profit Wastewater Alternatives & Innovations (WAI), to raise funding to kickstart a process leading to the statewide conversion of Hawai'i's cesspools.

Hawai'i Mesonet and the Hawai'i Climate Data Portal

In the past year, Giambelluca received support from the Honolulu Board of Water Supply, the Hawai'i Commission on Water Resource Management, and National Science Foundation for one of his long term goals, to establish a state-of-the-art network of telemetered weather and climate monitoring stations across the islands. Installation of the first of more than 90 Hawai'i Mesonet stations began in June 2022. This effort will expand on the existing HaleNet system of nine stations first established by Giambelluca in 1988. The Hawai'i Mesonet will be anchored to the Hawai'i Climate Data Portal (HCDP), an online resource launched in March 2022 to provide historical and realtime climate information including up-to-date high resolution digital maps of weather variables such as rainfall and temperature. The HCDP's development was led by a team of climate scientists, including Giambelluca, and IT specialists from UH's Cyberinfrastructure team, along with support from the NSF EPSCoR 'Ike Wai project. The Hawai'i Mesonet and HCDP will provide valuable data access for weather forecasting, water resource management, flood warning, irrigation management, and many other applications.

Cooperative Institute for Research to Operations in Hydrology

The National Oceanic and Atmospheric Association (NOAA) recently announced a $360 million award toward the establishment of a new water-focused center called the Coopertive Institute for Research to Operations in Hydrology (CIROH). WRRC leads a team of UH researchers as part of a consortium of 14 instutions, headed by the University of Alabama, that make up CIROH. The UH team is poised to begin working on an evaluation of National Water Model (NWM) flood forecasts in Hawai'i, and examining hyperlocal flood prediction in low-income communities underserved by the current flood forecast infrastructure.

"In a time where climate change and other human-related actions are severely impacting water resources and weather around the world, hydrological research has become paramount to creating sustainable and resilient management solutions," said UH Vice President for Research and Innovation Vassilis L. Syrmos. "The University of Hawai'i is pleased to be part of this important NOAA consortium and is well-represented by UH Mānoa's Water Resources Research Center and its cadre of multidisciplinary experts in weather- and water-related research."

For over five decades, the WRRC has conducted vital research on water-related issues, while remaining largely unseen and unknown to the public. Hopefully, that will change sometime soon.

TOP LEFT: *WRRC Director Tom Giambelluca at the Vaipito Weather Station in American Samoa*

BOTTOM LEFT: *The U.S. Navy's Red Hill Bulk Fuel Storage Facility on O'ahu continues to present challenges to one of the island's largest aquifers*
CREDIT: U.S. NAVY

TOP RIGHT: *REU undergraduate student Madison Anzarut and Microbiology graduate student Nuh Jahat Jabin collect water samples from the Kahalu'u watershed for microbiological analyses to evaluate the impact from cesspools*

MIDDLE RIGHT: *Research Assistant Jaline Seruge studies whether coliphages could be linked to pathogen-based health risk estimates and used as alternative water quality indicators*

BOTTOM RIGHT: *WRRC Postdoctoral Researcher Han Tseng conducts work on a 80-foot Hawai'i Mesonet station tower in Hawai'i Volcanoes National Park*

UH Applied Research Lab Powers Up

WITH HIGH PERFORMANCE COMPUTING FOR THE DOD

WHEN MOST PEOPLE THINK ABOUT KIHEI, MAUI, they envision year-round sunshine, sprawling white sand beaches and an eclectic mix of shops, restaurants and vacation condos. However, for Daniel K. Inouye, the late U.S. Senator from Hawai'i, what he had in mind was something entirely different. What the powerful and influential lawmaker saw was an opportunity to bring high-tech research and development to the state through the creation of a center for excellence in supercomputing.

In 1993, Senator Inouye's vision became a reality with the establishment of the Maui High Performance Computing Center (MHPCC), now one of five such centers in the country under the Department of Defense's High Performance Computing Modernization Program (HPCMP) that feature large-scale supercomputers, high-speed networks, multi-petabyte archival mass storage systems, and computational experts. The center has allocated more than 70 million computational hours annually to the HPCMP research, development, test and evaluation community. As part of the U.S. Air Force Research Laboratory (AFRL), the center also supports the telescopes of the U.S. Space Force's Maui Space Surveillance System atop Haleakalā that are used to view and track objects in space. It has been managed and operated by the University of Hawai'i (UH) since 2001.

Mission Transition

In 2017, the Maui High Performance Computing Center became part of the Vanguard Center for High Performance Computing (Vanguard Center) contract. The move marked the transition of the MHPCC from being primarily a pure computing resource center to becoming part of a "vanguard" of research and development in high performance computing systems and technologies under the management of the Applied Research Laboratory at the University of Hawai'i (ARL at UH).

The ARL at UH is a virtual center of excellence that conducts research; development testing and evaluation to address challenging and emerging problems for the Navy and national defense needs in core competency areas that include, ocean research, astronomy, sensor development, remote sensing, renewable energy, public service; and most recently—high performance computing. It was established in 2008 and is the fifth of five Navy-sponsored University Affiliated Research Centers (UARCs).

In May 2020, ARL at UH was awarded a four-year indefinite delivery/indefinite quantity contract by the AFRL to maintain essential engineering, research and development capabilities at the Vanguard Center by conducting scientific and technology investigations, providing scientific expertise, capabilities and facilities to turn basic theories into to deployable applications

LEFT: *New edge computing server being prepared for customer*

ABOVE: *MHPCC data center*

(Facing page)

TOP LEFT: *High speed networking is utilized for MHPCC supercomputing resources*

BOTTOM LEFT: *MHPCC systems staff collaborate to maintain supercomputing servers*

TOP RIGHT: *The MHPCC DoD Supercomputing Resource Center is located in the Maui Research and Technology Park in Kihei*

BOTTOM RIGHT: *Vanguard Center Executive Director Tiare K. Martin*

in the areas of sensor development, image processing, command and control integration, advance data visualization and analytics, machine learning and autonomy.

"Our tasking is essentially to lower barriers to usage of a modern high-performance computing ecosystem and high-performance computing backed systems," said Margo Edwards, director of ARL at UH. "Our work also allows the Department of Defense to leverage the core competencies of ARL at UH to accomplish research, test and evaluation of those systems."

Impressive Early Successes

With the emergence of more powerful computers, machine learning and data visualization, there has been a shift to re-engineer old systems and workflows into a digital format to increase collaboration, communication, efficiency and security. This shift, known as digital engineering (DE), is being embraced by many organizations. ARL at UH/Vanguard Center's role in the successful development and deployment of the U.S. Navy's effort, known as the Naval Leveraging Innovations, Frameworks and Technologies (LIFT) ecosystem, has garnered the attention of the other services and commands.

Today, with an endless flow of real-time data, the traditional computing paradigm built on a centralized data center and everyday internet is not ideal, often impaired by bandwidth limitations, latency issues and unpredictable network disruptions. Edge computing, which moves some portions of data storage and computational resources out of a central data center and closer to the user on the "edge," is steadily being implemented. Recently, ARL at UH/Vanguard Center successfully deployed a prototype edge computing system to support the United States Indo-Pacific Command and the U.S. Fleet Cyber Command as a part of the Pacific Ecosystem for Cybersecurity (PEcoC) initiative.

"The PEcoC project is evidence that ARL at UH/Vanguard Center has the ability and expertise to modernize high performance computing for the Nation and positively impact Pacific and National Joint Force efforts across the globe," said Tiare K. Martin, executive director of the Vanguard Center.

"The Department of Defense wants to leverage the innovation coming from research centers affiliated with universities, and ARL at UH and Vanguard Center are two pillars we can use to help grow the technology industry in Hawai'i."

High-Tech Workforce

Senator Inouye also saw high performance computing as a foundational driver for the establishment of a high-tech economic sector and workforce on Maui. Martin, who was named executive director in July 2021, is a prime example of his vision. Born and raised in Hawai'i, Martin earned her bachelor's degree in electrical engineering from the University of San Diego. After a stint at Raytheon's Space and Airborne Systems Center in California, Martin returned to Hawai'i to work as Maui site manager for Oceanit, a locally owned company specializing in creation of disruptive technologies. She joined the Vanguard Center as a program manager in 2017. Of the 37 current employees at Vanguard Center, 70 percent hail from Hawai'i.

"Through the ARL at UH/Vanguard Center the University of Hawai'i is addressing vital national defense needs while expanding our research enterprise into emerging technologies critical for the future," said UH President David Lassner, who has served as the program's principal investigator since 2001. "We are honored to be a steward of Senator Inouye's vision of a high-tech industry providing some of the best jobs on Maui."

Engineering a More Secure Future for Hawai‘i

FOR MANY DECADES, LOCAL INDUSTRY LEADERS HAVE VALUED and sought out the expertise of the University of Hawai‘i at Mānoa (UH Mānoa) College of Engineering on a multitude of important matters ranging from education to infrastructure, workforce development, and even finance. Now, with the onslaught of climate change issues and a rapidly approaching deadline to one of the country’s most aggressive clean energy mandates, these industries and organizations are again calling on the college to assist with critical issues that will help to ensure a more sustainable and resilient future in Hawai‘i.

“The University of Hawai‘i at Mānoa’s College of Engineering has always enjoyed a great working relationship with our local industry partners that is based on a mutual exchange of ideas, talent and responsible stewardship,” said UH Vice President for Research and Innovation Vassilis L. Syrmos. “Today, this valued industry partnership has become even more important as the state, the nation and the world require engineering-based solutions to mitigate the ever-increasing challenges brought about by climate change.”

Syrmos’ statement is validated by a recent anonymous donation of $2 million to UH Mānoa to study resiliency. The donation continues and advances the work of the late Alfred A. Yee, a world-renowned local engineer whose passion was finding a way to provide clean, cost-effective sources of energy to small island communities. The gift provides ongoing funding to recruit and retain outstanding faculty with expertise in sustainability and resilience, fueling competitive research, engineering-sector resiliency solutions and teaching in these critical areas.

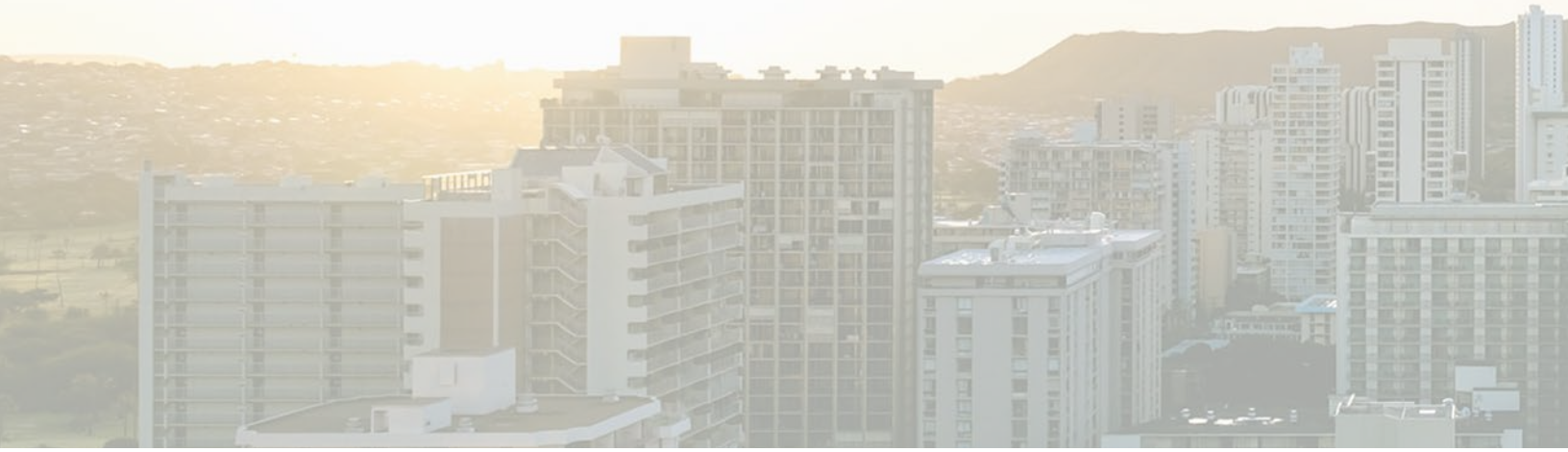
Brennon Morioka, dean of the UH Mānoa College of Engineering, views this contribution as a “vote of confidence” by the local community that the University of Hawai‘i can and should lead on many fronts related to the challenges Hawai‘i faces.

The sentiment is echoed by Ken Hayashida, founder of the Honolulu-based structural and forensic engineering firm KAI Hawai‘i. “The University of Hawai‘i is key to providing us with young people who are committed to change our community for the better,” said Hayashida. “That’s going to require all of us to invest in our university so we have young people who can lead, innovate and provide us a safe, sustainable and resilient community to live in.”

Recognizing the UH Mānoa College of Engineering’s contributions to his industry and Hawai‘i at large, KAI Hawai‘i has given $250,000 to the college to endow a new Vertically Integrated Project (VIP) related to sustainability and resilience. VIP projects are long-term research projects made up of undergraduate students who work under the supervision of faculty and graduate students. This program gives undergraduates the rare experience of conducting research in engineering with the intention that they will use the innovative out-of-the-box thinking skills they learned when they graduate and enter the industry.

The goals of this new VIP project are to help support broad UH energy and sustainability efforts, including becoming net-zero energy by 2035 and carbon neutral by 2050. Specifically, the team will be working on:

- PV system battery performance verification on the campuses of UH Maui College, Leeward Community College, and Windward Community College
- UH metering data analysis: individual building energy consumption is to be correlated with weather patterns to detect anomalies and help reduce overall energy consumption.
- Occupancy monitoring and HVAC data analysis of UH Mānoa’s Sakamaki Hall will be obtained using Doppler radar-based sensors to provide a baseline for more efficient HVAC scheduling
- Data analysis to study the correlations of indoor and outdoor environmental parameters with occupancy patterns and energy use in Flexible Response to Ongoing Growth (FROG) buildings



While those programs have not commenced yet, a team of UH Mānoa College of Engineering faculty has already begun to help to improve the lives of Hawai'i residents. In 2019, a team of UH engineering professors led by Oceana Francis and the late Horst Brandes produced a Statewide Coastal Highway Program Report for the State Department of Transportation's Highways Division. Using a new approach, the team ranked the twenty most vulnerable locations in Hawai'i for purposes of road management and planning.

"The results show that the methodology proves useful and promising for government-, state-, and county-level road authorities and agencies in the assessment of the coastal road erosion problems and their decision making with regard to remediation measures," said Francis. "I also bring these projects into my classroom where the students get to learn about these projects and the tools to do the work."

The private sector has also taken notice of the UH Mānoa's College of Engineering's potential for solving Hawai'i's challenges.

First Insurance Company of Hawai'i (FICOH) has expressed an interest in working with the college to better anticipate longer-term risk management for aging buildings and thereby helping to control the cost of housing for Hawai'i's residents.

"As Hawai'i's condos age, they become more susceptible to devastating water and fire losses," said Drew Nagai, assistant vice president of Risk and Safety Management at FICOH. "Working with our academic partners at the UH Mānoa College of Engineering, our goal is to use our shared knowledge to make maintenance recommendations to the condominium associations (AOAOs) that will help to decrease the frequency and severity of condo losses, improve access to insurance, and make Hawai'i a more affordable place to live for future generations."

Morioka appreciates this support and points out that Hawai'i's reliance on the UH Mānoa College of Engineering is nothing new nor is it likely to end any time soon.

"Hawai'i's public and private sectors have been rallying around the UH Mānoa College of Engineering, from hiring our graduates for employment to fill the growing demands of an engineering workforce in Hawai'i to working with our faculty and students on solving real-world problems our government agencies and private sector partners are facing today that require immediate solutions," said Morioka. "Our college has become the go-to resource for many things from sustainability and resilience issues, helping Hawai'i achieve its renewable energy goals, researching 5G and broadband communication capabilities, advancing autonomous vehicle technologies, partnering in clinical research for biomedical innovation, cyber security and new digital infrastructure, aerospace, and space exploration, and even astronomy—working in the observatories right here at home."

Professors Oceana Francis and the late Horst Brandes conferring on the condition of erosion along Honoapi'ilani Highway along Maui's southwestern coast.

HiPAM

BORN OUT OF NECESSITY

AS COVID-19 CASES WERE RAPIDLY ESCALATING IN 2020, a group of University of Hawai'i (UH) faculty and students were gathering behind the scenes, feverishly working on a new collaborative effort that would help to understand the trajectory of the pandemic in Hawai'i and therefore control it better.

"In the beginning, there was so much confusion," said Victoria Fan, director of Pacific Health Analytics Collaborative and associate professor of health policy at the University of Hawai'i at Mānoa (UH Mānoa). "Evolving science of a new disease and confusing numbers and data offered limited explanation as to what all this constantly changing information meant for families, communities, or public policy."

COVID-19 specific models, whose primary goals are to extract and provide meaningful insights from data including possible scenarios depending on non-pharmaceutical interventions as well as forecasts and predictions, started to be developed and used around the world. These models helped to analyze data and help to predict the potential impact of certain policy decisions, as well as forecast and predict COVID case counts and hospitalizations to help countries better respond and prepare for spikes in cases and healthcare needs.

"We were monitoring national and international models, but none were directly relevant to Hawai'i, and yet these national models—some without accurate Hawai'i data—were impacting major policy decisions and actions of our community," added Fan, who founded and has chaired the Hawai'i Pandemic Applied Modeling (HiPAM)—a volunteer working group of applied epidemiologists, data scientists, health workers and professionals committed to adapting tools to inform data-driven decision making and planning since April of 2020.

A Quiet and Humble Start

HiPAM started in 2020 behind the scenes. One of those early models had predicted that Hawai'i would be hit with a surge that would require additional healthcare capacity. That opened up a debate about retrofitting the Hawai'i Convention Center to serve as an acute care facility. The state Hawai'i Emergency Management Agency (HI-EMA) assigned Thomas Lee as lead epidemiologic adviser and gave him just a few hours to advise whether or not it was necessary.

Having adapted a national epidemiologic data model using local data, Lee was able to forecast that Hawai'i would not see a major surge and did not require retrofitting a stadium for an acute care facility. With no immediate surge in May of 2020, the state was able to save millions in funding that was diverted for use on other important COVID-19 efforts.

Not long after, HiPAM launched its ongoing two-week COVID-19 forecast on its website in July of 2020. After that, there were several cases where HiPAM's forecasts were used for informing decisions, initially behind the scenes to policymakers in 2020 and later shared directly to the public from 2021 onwards. At each juncture and surge of the epidemic, HiPAM earned credibility through the accuracy of its forecast, buttressed by a brain trust and technical advisory group that helped to properly and nimbly build, interpret, understand, and use COVID-19 models throughout Hawai'i's pandemic.

"HiPAM's accurate estimates allowed the state to be proactive rather than reactive, resulting in reduced deaths and human suffering," said Major General Kenneth Hara, director of HI-EMA and the state's incident commander for COVID-19 pandemic response. "Their efforts, especially their modeling products, were invaluable when making decisions and policy recommendations. Their team of experts and professionals continuously demonstrated flexibility and the desire to improve their modeling methodology and products."

Becoming a Trusted Voice

HiPAM focused on being accurate and trustworthy, nimble and timely. Unlike other models being developed on the mainland and abroad, the HiPAM model delivered ongoing two-week forecasts versus the more common, multi-month forecasts, which would become obsolete within weeks due to ever-changing data, government policies, human behavior and other factors. Rather than get embroiled in tense political discourse, HiPAM emphasized the communication of an unbiased forecast without advocating a policy recommendation. Rather, HiPAM repeatedly emphasized that forecasts are just one piece of information that policymakers and the public need to make decisions.

By 2021, a model developed by UH Mānoa Department of Mathematics Professor Monique Chyba and her students allowed HiPAM to refine its statewide forecasts based on Hawai'i's unique demographic, geography, culture and industry impact, eventually leading to county-specific forecasts as well.

"We learned mitigation measures should be really targeted and localized to be more effective, not just for the state but for each county," said Lee, HiPAM co-chair. "Having HiPAM members from across the UH System

LEFT: *HI-EMA Director Maj. Gen. Kenneth Hara with UH Mānoa Mathematics Professor Monique Chyba and her students*

and other organizations really helped us to develop a Hawai'i specific, more holistic model and approach."

Fan and Lee noted some of the invaluable contributions made by members of this multi-disciplinary group. Chyba and other UH faculty improved the modeling, Marguerite Butler of UH Mānoa's Department of Biology helped the team to better understand how disease testing lineages and mutations could potentially affect the data, and those from neighbor islands like UH Maui College STEM faculty Tom Blamey and Kaua'i District Health Officer Janet Berreman provided important perspectives on their respective county's situations and needs. Istvan Szapudi and Lee Altenberg from astronomy and computer science had mathematical insights about COVID's unique spread, such as its superspreading aspect. Community partners such as Hawai'i Health Information Exchange (Francis Chan), Queen's Medical Center (Roy Esaki and Kiyoshi Shiraishi), and Hawaii Medical Service Association (Brian Wu), and others were regular HiPAM contributors and members.

"No one expert or authority could presume to have complete expertise," said Fan, when discussing the HiPAM's diverse background—academics and professionals in epidemiology, data science, computer science, mathematics, health care, and aging.

She added, "With a new disease, we all learned from each other. It was amazing to see the brilliance of the team. It really showcased the wealth of knowledge the University of Hawai'i has to offer. We were able to de-silo systems and protocols—bring together different fields and industries, share information, skills and expertise—and just get things done."

"HiPAM demonstrates that UH is able to play a gap-filling role in using our expertise and sharing science and knowledge in a way that directly benefits the community."

Other countries also benefited from their own pandemic modeling advisory group—Ireland, the United Kingdom, Australia, among others. Hawai'i is notable for having its own modeling expertise within the state despite its smaller size.

Workforce Development

"One of the biggest milestones of HiPAM was the workforce training opportunities for our students," said Chyba, who at any given time had up to 10 undergraduate and graduate students working on refining the modeling. "There are few opportunities for pure mathematics programs to engage in actual, concrete and timely challenges, and our students played a major role in these efforts."

HiPAM's success in showcasing the impact and real-world application of mathematics reinforces the need for UH Mānoa College of Natural Sciences' newly developed tracks. Both its mathematics and information and computer sciences departments have implemented data sciences tracks, and the mathematics department is implementing a new computational science track in Fall 2022. These new tracks are focused on helping students develop desirable skills that can be applied to other industries and government organizations, and grow data-driven careers in Hawai'i.

The Future

While the COVID-19 pandemic has been downgraded to an endemic status, the virus is still prevalent and many long-term issues magnified by the crisis remain, including substance abuse, mental health, aging, and unemployment. Additionally, it has been suggested that more pandemics are on the horizon due to the effects and shared causes of climate change, among other reasons.

However, with its funding coming to an end and its volunteer corps exhausted from over two years of non-stop work, HiPAM went on hiatus at the end of June. Whatever direction the state decides for its future, HiPAM has proven under fire that its multi-disciplinary think tank composed of UH experts and the community can successfully and nimbly collaborate in times of need.

"Hopefully, this will grow into something bigger, better and more permanent for our state," added Chyba. "In either case, our science is not going away, our students are not going away, and we'll keep working to improve on our research."

(Facing page)

LEFT: *Contrails from the use of conventional jet fuel contributes to atmospheric warming*

MIDDLE: *Biofuel made from waste woody biomass* CREDIT: PETER MATLOCK

RIGHT: *UH Hilo Academic Support Specialist Jake Rodrique harvests seed cane for a study on growing sugarcane for jet fuel* CREDIT: UH HILO

ALAKA'I

UH HILO'S NEW BIOECONOMY ACADEMY

IN THE FACE OF CLIMATE CHANGE AND ITS DEVASTATING EFFECTS TO THE PLANET, including severe drought, unprecedented rainfall, catastrophic flooding, sea level rise, and an increase in superstorms worldwide, humankind is facing one of its greatest and most complex challenges to date. However, an even greater challenge will be to get the world to transition from a dependency on fossil fuels to a sustainable, circular economy that provides renewable and clean sources of energy, fuels, materials, chemicals and other necessities of daily life.

Biomanufacturing and the bioeconomy, defined as the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, is an important step toward replacing fossil fuels to reduce greenhouse gas emissions linked to climate change. This transition would be unprecedented in scale, societal impact and urgency, and requires heightened leadership and extraordinary public participation.

"Leaders who drive our transition away from fossil fuels must be knowledgeable in a wide range of disciplines, from sustainable agriculture to biomanufacturing, from business to policy, as well as in social-economic and cultural issues of appropriateness, equity and justice," said Peter Matlock, bioeconomy research and commercialization specialist for the University of Hawai'i at Hilo (UH Hilo). "Most importantly, informed and thoughtful perspectives on sustainability are required to serve as guiding principles in navigating the uncharted waters to attain environmentally and economically beneficial outcomes."

The Applied Life-Science Academy: Knowledge Advancing Industry (ALAKA'I) program at UH Hilo seeks to train and prepare leaders, professionals, students, and the community for this transition. The ALAKA'I program, building on the Hawaiian term for "guide or leader", is developing short, bootcamp-style training sessions that will broaden awareness of how to advance the bioeconomy.

The ALAKA'I Academy is a partnership between UH Hilo's College of Agriculture, Forestry and Natural Resource Management (CAFNRM), the non-profit BioMADE, the National Corn-to-Ethanol Research Center (NCERC) at Southern Illinois University at Edwardsville (SIUE), and Dr. James DeKloe of Solano Community College. BioMADE is a public-private partnership with over 125 university, community college, and industry members who are collaborating to advance bioindustrial manufacturing. NCERC is the nation's "go-to" facility for demonstrating biomanufacturing technologies at larger scale, with extensive student training programs in biomanufacturing. Dr. DeKloe pioneered the biomanufacturing community college curriculum that set national standards, and also established the two-year Associate's and four-year Bachelor's degree programs in biomanufacturing at Solano Community College in Fairfield, California.

The ALAKAI courses are being developed through extensive interaction with a number of bioeconomy companies and research organizations to ensure relevance, meaning, and impact. The one-week bootcamp format will be broadly accessible and will provide participants with targeted learning that can deepen their understanding within their professional discipline and/or across other disciplines necessary

to implement beneficial change. ALAKA'I will be offered on an experimental basis over the summers of 2022 and 2023, after which technology and business training will be formally offered to the public on an ongoing basis by UH Hilo, its team members, and other interested institutions nationally. Courses addressing Hawaiian and Pacific Island culture will remain in Hawai'i to maintain the appropriate sense of place.

Indigenous Native Hawaiian and Pacific Island cultural perspectives and knowledge are central to the program to provide deep insights into what it means to be sustainable and how to translate sustainability objectives into effective, contemporary solutions. Angela Fa'anunu, assistant professor of Sustainable Tourism at UH Hilo, is exploring Native Hawaiian and Pacific Island cultural perspectives to develop curriculum that emphasizes resiliency and adaptation to the environment. She believes the ALAKA'I program can play a unique and critical role in conveying these perspectives to develop a bioeconomy that is inclusive and respectful of the environment.

"Diverse perspectives are particularly important when trying to solve complex and deep-rooted issues," said Fa'anunu. "Hawaiian and Pacific Island societies are land-based, and people relate to each other and to their natural resources in different ways than current Western approaches."

Bioeconomy solutions are integral to the "all-hands-on-deck" approach necessary to address climate change. For example, biofuels remain essential in transportation, especially for aviation where there are no alternatives to liquid fuel for long-haul flights. Sustainable aviation fuels now being scaled up from research labs, have performance superior to petroleum-based conventional jet fuel, with higher energy densities that enable more passengers and freight to be flown over more miles from each gallon of fuel. These bio-based fuels are compatible with the existing airline fleet and eliminate aromatic hydrocarbons, burn cleaner to reduce particulate emissions, eliminate contrails that contribute to atmospheric warming, improve worker safety, and reduce engine maintenance costs by eliminating soot build-up.

Additionally, new agronomics are being developed to sustainably produce biomass feedstock to make carbon-negative biofuels that actually draw down atmospheric greenhouse gas levels with each gallon of fuel used. A groundbreaking study investigating the growth of certain cultivars of sugarcane for conversion into high-performance jet fuel is currently underway at UH Hilo. With support from the U.S. Department of Agriculture, CAFNRM researchers are studying the feasibility of growing substantial amounts of cane biomass without traditional tilling or plowing to minimize inputs and farmer costs that will help to maximize biomass production, improve soil health and potentially reduce atmospheric carbon dioxide levels.

"The aviation industry recognizes that bio-based, or sustainable aviation fuels are essential to the future of aviation," said Bruce Mathews, dean of UH Hilo's CAFNRM and principal investigator of the project. "Fully one-half of the industry's greenhouse gas reduction goals for 2050 can only be achieved via sustainable jet fuels."

Bio-advantaged molecules harness the power of biological synthesis to make products that are infeasible to obtain from petroleum. Renewable, fully biodegradable, and/or infinitely recyclable plastics can directly address the world-wide problem of plastic waste build-up by diminishing pressure on limited landfills and more importantly—protect wildlife and humans from plastic ingestion and biosphere invasion. Bioeconomy products can also save wildlife directly. It is estimated that the biomanufacture of squalane, used primarily in cosmetics as moisturizer, from less than two hundred acres of sugarcane can save the lives of approximately two to three million sharks, whose livers currently serve as the primary source of the emollient.

According to reports by the McKinsey Global Institute and Schmidt Futures, it is estimated that the bioeconomy can grow to as high as $4 trillion in the next 10 to 20 years and UH Hilo and its partners intend for ALAKA'I to help advance this tremendous growth.

"The bioeconomy is critical to building sustainable communities, and agriculture plays the starring role in providing sustainable biomass feedstock to make bioeconomy products," said Mathews. "The ALAKA'I program helps place Hawai'i at the forefront of promoting solutions to climate change at a local, national, and global level."

"This is a critical opportunity to examine what we mean by sustainability. Although we think we understand how to define sustainability, it can rapidly become ambiguous when choices become difficult and complex," said Matlock. "We are extremely fortunate that Dr. Fa'anunu is leading the effort to explore indigenous perspectives to identify more durable and deeper guiding principles of sustainability to appropriately advance the bioeconomy through the ALAKA'I program."

Incubating Ideas for the Real World

IMAGINE A WORLD WITHOUT TVs, computers, Google, insulin, vaccines, ultrasounds, or rocket fuel to power spacecraft to the moon and beyond. Origins of the internet and all wireless communications today actually stem from a computer networking system developed at the University of Hawai'i (UH) more than 50 years ago.

If it were not for university research, these world-changing technologies would not have been invented, developed or perfected. And if it were not for entrepreneurship and commercialization efforts, many of these innovations would still be sitting within university walls.

"University of Hawai'i faculty, staff, students and alumni are developing world-class research and technology that have the potential to make a real impact on society and improve our way of life," said Vassilis L. Syrmos, vice president for research and innovation at UH. "The role of our Office of Innovation and Commercialization is to help UH faculty and students translate their research and innovations into commercial opportunities that can benefit our local and global communities and economy."

However, traditional accelerator and incubator programs cater to business savvy, full-time entrepreneurs, not academics whose jobs are to focus on research, teaching and technology. In response, this year the Office of Innovation and Commercialization (OIC) soft-launched a new innovation incubator this year, unlike any other program available.

Focused on long-term growth versus short-term investment, OIC's innovation incubator addresses the unique needs and demands of UH faculty, students and alumni. Instead of quick, cookie-cutter training, the program provides concierge guidance, coaching and support to advance academics' startup journeys over a 12- to 24-month period.

"We're focused on supporting 'deep-tech, high-impact' technologies developed throughout the University of Hawai'i System," said Steve Auerbach, OIC interim director.

"Our program is customized to support our diverse faculty, staff, students and alumni. We hope to dramatically shift the traditional academic pathway by nurturing a culture of entrepreneurship that will help us to expand Hawai'i's innovation ecosystem and build a new economic driver for the state."

The inaugural Spring '22 cohort includes three renewable energy startup companies—Hawai'i Innovation Lab, Nimbus AI and Renewable Edge—who are all developing groundbreaking technologies that offer solutions to the growing and imminent need for renewable and sustainable energy sources worldwide.

"As an academic, I am particularly excited to participate in a program that has academics in mind," said Giuseppe Tori, Spring '22 cohort participant, Nimbus AI co-founder and Department of Atmospheric Sciences assistant professor. "I think that the long-term view and the goals that the program's amazing staff are helping us achieve are tailored to our experience, and I believe this is extremely valuable."

Developed and operated by seasoned entrepreneurs and innovators, the incubator program allows each cohort to customize their curriculum and training, while mapping out personalized pathways and opportunities.

Cohort participants also meet with OIC's innovation incubator team weekly to check in and discuss everything from their technology and funding opportunities to work-life balance and mental health.

While most programs commonly discuss and focus on the funding or financial runway, they rarely address the emotional aspects of entrepreneurship. A large portion of this program is dedicated to mentoring and coaching each individual participant on a "whole entrepreneurial" level, including their technology, where they are in their startup journey, what they need, where they may succeed, and especially how they think and will thrive.

"I've learned that entrepreneurship is a difficult and sometimes lonely journey, especially while crossing the Valley of Death that stands between research and successfully bringing it to the market," said Arif Rahman, Spring '22 cohort participant, and co-founder and CEO of Hawai'i Innovation Lab. "Since joining this program, I feel there is always someone to seek guidance while making critical business choices. The longer duration of the program and support system also helps reduce the fear of failure."

In addition to helping cohort participants define their business acumen, company culture and customer discovery, OIC is also helping each participant enhance their operations and outreach, and most importantly, secure cash flow through investment capital or non-dilutive federal grants like Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR).

As a recent guest speaker for the program shared, "federal grants are good, but getting an industry customer to fund you to solve a problem they have is much better customer validation."

Upon securing an SBIR/STTR and matching funds during the program, each cohort company may receive up to $25,000 from OIC upon securing a matching award from Hawaii Technology Development Corporation (HTDC). That is in addition to the $25,000 in initial, milestone-based seed funding they receive from OIC through its UH Ventures fund.

"Supporting our cohort participants in generating early revenue is key to helping grow their business and encouraging seed-stage investors to invest in UH affiliated startups," added Auerbach.

"This program has been critical in helping me navigate and gain confidence in the entrepreneurship journey with the end goal of placing our engineering ideas into meaningful real-world application," said Kevin Davies, Spring '22 cohort participant of Renewable Edge. "I believe the program is especially effective because it puts business and financial concepts into terms that are much easier for engineers and scientists to understand, appreciate, and ultimately put in practice."

Over the remaining 20 months of the program, cohort participants will continue to pursue both federal grants and other private funding opportunities, while focusing on refining their customer discovery, messaging and outreach.

"OIC's innovation incubator program is deeply grounded in Hawai'i, and through many on-island networking opportunities, it is helping us drive innovation and add value to the local communities that we feel committed to," added Torri.

OIC will be launching its second, Fall '22 cohort later this year. The program is available to UH System faculty, and staff, as well as students and alumni partnered with faculty or staff who are part of a UH-affiliated startup company that is developing deep-tech innovations originated or developed through UH research. For more information about the program, visit research.hawaii.edu/oic/ideationstudio or email ideation@hawaii.edu.

OIC's innovation incubator is supported by the U.S. Economic Development Administration (EDA) through a $2.7 million CARES Act Recovery Assistance grant. Seed funding for participants is provided by UH Ventures, LLC.

HAWAI'I INNOVATION LAB

Hawai'i Innovation Lab (HIL) was co-founded in 2020 by a team of postdoctoral researchers, professors and graduate students at the University of Hawai'i: CEO Arif Rahman, CTO Aaron Ohta, Kareem Elassy, Nalu Matthews and Wayne Shiroma.

Since then, the company has raised more than $525,000 in pre-seed funding through national and local accelerator and grant programs and competitions including: National Science Foundation's (NSF) Innovation Corps (I-Corps); U.S. Department of Agriculture Phase I SBIR; American Made Solar Prize; and the Pacific Asian Center for Entrepreneurship (PACE) 2017 Breakthrough Innovation Challenge.

HIL is working on developing an advanced reflective coating that is far more manufacturable and cost effective than the traditional coatings used for solar thermal technologies such as concentrated solar power (CSP). CSP offers higher efficiency power generation potential than photovoltaic (PV) because of its ability to produce and store thermal energy, which enables power generation during cloud cover and after sunset.

NIMBUS AI

Nimbus AI was started by Geoff Galgon, computer science PhD student Kyle Hart, Information and Computer Sciences Assistant Professor Peter Sadowski and Atmospheric Sciences Assistant Professor Giuseppe Torri.

The company is developing artificial intelligence systems for predicting solar irradiance a few hours to days ahead. This has profound implications for the energy grid as more renewable sources are added which vary with weather. Improved forecasting enables utility operators to maintain energy grid stability via demand response and dynamic pricing. This is especially important for isolated grids with a lot of renewable sources, like in Hawai'i.

Another participant of NSF I-Corps, winner of PACE's 2020 Breakthrough Innovation Challenge and recent finalist of the American Made Solar Forecasting Prize, Nimbus AI has so far won over $70,000 in prizes to grow its company.

RENEWABLE EDGE

Kevin Davies, a UH Hawai'i Natural Energy Institute assistant researcher founded Renewable Edge in 2022. The company is designing adaptable, smart devices to monitor and improve electric grid performance. These devices provide real-time data, analytics and controls to optimize the integration of renewable energy alongside smart appliances, electric vehicles and home battery systems. This technology will help utilities and system operators leverage the ongoing decentralization of electric grids, while increasing resiliency and sustainability.

Eleanor Sterling

HIMB'S NEW DIRECTOR BRIDGES BIOLOGICAL, SOCIAL AND CULTURAL STUDIES

ELEANOR STERLING FELL IN LOVE WITH LANGUAGES at an early age and had intended to study linguistics when she arrived at Yale University. However, through an undergraduate course in physical anthropology, Sterling discovered another love — a love of science.

"Up to that point, I really didn't believe that the sciences were for me," said Sterling who has since studied over ten languages. "I found out that I absolutely loved it and became excited about what science was and could become."

Fortunately, that turn of events on the New Haven, Connecticut campus would eventually lead Sterling to the University of Hawai'i at Mānoa (UH Mānoa), where she became the new director of the Hawai'i Institute of Marine Biology (HIMB) in January 2022.

Prior to arriving at UH Mānoa, Sterling spent 26 years at the American Museum of Natural History in New York City, most recently as Jaffe Chief Conservation Scientist. A highly regarded researcher and conservationist, Sterling's vast expertise ranges from conservation biology to international policy to the ecology of endangered species and ecosystems to the confluence of language, culture, and biodiversity to strategic planning and evaluation. She has spent all of her academic career balancing biological, social, and cultural studies.

Sterling learned about the importance of listening to other ways of knowing starting in Madagascar, where she has worked on and off since 1983 to better understand the links between biological and cultural diversity. She lived for several years in a tent, without electricity on an uninhabited island in order to study a nocturnal lemur — the aye-aye — that was thought to be one of the most endangered primates in the world. She not only studied its ecology and behavior, but also how aye-ayes fit within the knowledge systems of the different ethnic groups within Madagascar.

"I believe that understanding the linkages between biological and cultural diversity — taking what some call a biocultural perspective — is crucial to effective management of healthy human and non-human communities," said Sterling, who also worked with local scientists and educators to rewrite the national primary school science curriculum to provide up-to-date science on local biodiversity.

Armed with lessons learned from Madagascar, Sterling later traveled to Vietnam to lead an initiative to help inform decision makers on the placement of nature reserves to maintain or increase biodiversity. Made up of a multidisciplinary team of scientists and educators, the group also addressed the potential impact of the proposed reserves on local communities. While there, Sterling also created multiple opportunities for young scientists to learn and share, many of whom are now leaders in their respective fields. To honor her investment in developing the capacity of young scientists in the country, herpetologists named a rare toothed toad after her called, Sterling's Toothed Toad *(Oreolalax sterlingae)*, a lovely

ABOVE: *HIMB, located on the island of Moku o Lo'e in Kāne'ohe Bay, O'ahu, is surrounded by 60 acres of coral reefs that are part of a Hawai'i State marine refuge*

(Facing page)

LEFT: *Working on sea turtle conservation efforts*

TOP RIGHT: *Sterling arrives at HIMB and is officially welcomed as its director*
CREDIT: LAULE'A BRANCO

MIDDLE RIGHT: *In Vietnam, Sterling led a multi-disciplinary initiative to assist decision makers with the placement of nature reserves to maintain/increase biodiversity*

BOTTOM RIGHT: *Eleanor Sterling, PhD*

brownish-gold toad that has only been seen by scientists at the summit of the highest mountain in Vietnam.

Sterling is no stranger to Hawai'i, as she came to the state decades ago to visit with her aunties on her father's side and subsequently worked here and elsewhere in the Pacific on sea turtle conservation initiatives. Her most recent work focuses on how local perceptions and values of health and well-being in Pacific Island countries differ from those promoted at international levels such as the Sustainable Development Goals.

"This work informs management of marine and coastal systems worldwide as well as providing the framework for sustainable development at community, national, regional, and global levels," said Sterling. "My UH Mānoa colleagues were strong collaborators in the Pacific-based initiatives and working more closely with them drew me to the HIMB position."

Sterling came to HIMB because of her admiration for the faculty's remarkable depth and breadth in marine research and education and because of UH Mānoa's pledge to become a Native Hawaiian place of learning. She is interested in exploring how to promote HIMB as a place where people of diverse backgrounds, perspectives, and ways of knowing can work together to foster resilience at the local and global scales across marine and coastal systems. HIMB's unique physical setting, with ready access to reef and coastal systems and its emerging collaborations with local Hawaiian communities on indigenous marine and coastal resource management, make it ideal for bridging across biological and social systems.

Sterling envisions HIMB being part of University of Hawai'i's efforts to serve as a hub connecting the Pacific Rim and Asia to the United States, particularly in exploring the links between biological and cultural diversity.

"Hawaiians and other Pacific Islanders have much to teach the world about health and resilience in the face of change, whether biological, cultural, social, or economic," said Sterling. "There are few places in the world better suited to cutting edge science and education and exploration of multiple knowledge systems, of multiple ways of knowing, of what that means for basic understanding of the world and for practical application of knowledge to decision making and action."

Sterling greatly values the ongoing research and education at HIMB and hopes to encourage more cross-disciplinary work and interaction within HIMB, across the UH System, and beyond. She envisions supporting artists and practitioners in residence at HIMB, creating a convergence zone for ideas and for synthesizing across multiple knowledge systems and re-envisioning the role and potential of a globally recognized center of excellence for marine studies and education. Sterling believes that these efforts to make connections across disciplines and viewpoints are how humankind will work to address the major challenges that it faces today including climate change, biodiversity loss, and erosion of knowledge systems.

"Eleanor Sterling checks all the boxes of HIMB director with her expertise in biological conservation, scientific research, environmental education, and program administration," said Professor David M. Karl, world-renowned UH oceanographer and chair of the search committee. "She is the embodiment of interdisciplinarity and we are pleased to have her as part of our UH Mānoa research 'ohana (family)."

UH Mānoa Gifted $50M for Ocean Sustainability and Resilience Research

AS A MAJOR BOOST TO ITS WORLD-CLASS RESEARCH EFFORTS ON OCEAN SUSTAINABILITY AND RESILIENCE, the heralded School of Ocean and Earth Science and Technology at the University of Hawai'i at Mānoa (UH Mānoa) received a $50 million pledge from Facebook Founder Mark Zuckerberg and his wife, Priscilla Chan in January 2022.

"Hawai'i has one of the richest marine ecosystems in the world—and having a deeper understanding of this ecosystem is the key to preserving and protecting it," said Zuckerberg and Chan in statement. "We're honored to support the University of Hawai'i's conservation efforts, including their trailblazing research on coral reef restoration, the impact of climate change on coastal waters, and other areas related to the health of our oceans."

The gift, which represents the largest cash donation in UH Mānoa history, will be leveraged by the Hawai'i Institute of Marine Biology (HIMB) to fund various research programs that will range from the monitoring of changing ocean conditions, developing solutions to support ocean ecosystems and marine organisms, and enhancing coastal resilience from storms and sea level rise. Known for its world-renowned research on coral reef restoration and ocean acidification, HIMB will also seek to expand community partnerships and indigenous resource management practices to educate and train future generations of coral and ocean conservation scientists.

University of Hawai'i (UH) President David Lassner called the Chan-Zuckerberg gift "transformative" and said it would allow the UH's world-class experts to accelerate their conservation research efforts. Lassner added, "There is no place on Earth better than Hawai'i to do this work, and no institution better able than UH. We could not be more grateful for the investment of Priscilla Chan and Mark Zuckerberg in a better future for all of us and our planet."

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