Throughout history, the world has faced numerous health crises that have tested the mettle and resolve of its citizens—the Spanish flu, measles, polio, HIV/AIDS, SARS and Ebola. Today, our world is confronted by the COVID-19 pandemic, an unprecedented health crisis that has rapidly spread across continents, overwhelmed modern health care systems and caused widespread disruption of the global economy.

Hawai‘i with its heavy dependency on tourism, is now at an economic crossroad. With high hotel vacancies, idled tour operations and restricted air travel, other businesses such as restaurants and retail stores are also suffering from almost non-existent visitor counts. Even after a vaccine for COVID-19 is developed or the effects of the disease are mitigated, the “new normal” may suggest that changes to the travel industry and in visitor habits could result in smaller or diminishing returns from the state’s primary industry.

Economic diversification is not only key to Hawai‘i’s economic recovery from the pandemic, it is also vital to its long-term economic stability and health. As one of five priorities set forth in its Strategic Directions, 2015-2021, the University of Hawai‘i (UH) embarked on an initiative to energize economic development through the commercialization of UH-based research and innovation. By pivoting the focus of its world-class, cutting-edge research enterprise to better address critical areas of importance, including: health and wellness, climate change, food and water security, energy, cybersecurity, big data and other areas of growth—UH continues to collaborate with various stakeholders in industry, government and business to diversify the state’s economy through startup and entrepreneurial activity necessary for the development of this new economic sector and its associated workforce.

As we all continue to battle this world-wide health crisis, it is understandable that medical research has been thrust into the forefront of public awareness. However, UH faculty and students are continuously pursuing other equally important areas of research to help improve lives in our state, our nation, the world and perhaps—even in space. In this issue of Noelo, please take a look and enjoy a brief snapshot of our valuable research to see what makes the University of Hawai‘i—like no place else on Earth.
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Water and Habitability
THE HUNT FOR EARTH’S ORIGINS

NO ONE KNOWS HOW WATER — THE WELLSPRING OF LIFE — ARRIVED ON EARTH. No one knows if the Solar System, with a planet possessing the necessary ingredients for life within the habitable zone, is a cosmic rarity. Nor do scientists know whether the gas giants in the Solar System played a role in delivering essential materials to the habitable zone. The answers to these questions are contained in volatiles unaltered since the formation of the giant planets. Comets were long thought to be the most likely “delivery service” of Earth’s water. But new models and new data, including data from the Rosetta comet mission have cast some doubt.

Right now, astronomers are on the cusp of directly observing the process of habitable planet birth around other stars. The next generation of observatories will reveal details of the disk chemistry and planet growth in the regions where habitable worlds form. The only way to get similar data for the Solar System and learn where Earth’s water came from is to match the chemical fingerprints of inner solar system volatiles to a location in the protoplanetary disk (rotating circumstellar disk of dense gas and dust surrounding a newly formed star). Such data can distinguish between competing models of solar system formation to specify where the water came from and how it was delivered. Astrobiologist Karen Meech, at the University of Hawai‘i at Mānoa’s (UH Mānoa) Institute for Astronomy (IFA) and her team are using astronomy, planetary science, geology and astrobiology to explore these questions of where Earth’s water comes from.

Clues to Earth’s Past from Deep Inside the Earth
The idea that comets were the source of Earth’s water arose in the 1980s when the Giotto spacecraft flew through the cloud of gas surrounding Halley’s Comet. Its sensitive detectors showed that the comet’s water was enriched in deuterium, a heavy isotope of hydrogen, found in abundance in the earth’s oceans. In the 4.5 billion years since the Earth formed, surface water has undergone a lot of processing through volcanic recycling, atmospheric escape and interaction with biology. "It didn’t seem logical that today’s oceans
An international team of scientists, led by UH Mānoa’s Karen Meech, are developing a NASA Discovery-class mission concept called Proteus to explore Main Belt Comets that should yield key missing information about the processes that created a habitable planet in Earth’s Solar System.
should match the D/H (ratio between deuterium and hydrogen in water that yields information about its origin and geologic history) chemistry of the primordial water present at Earth’s formation,” said Meech. “During a geological field trip exploring Icelandic hot springs one of the guides said that the escaping water vapor plumes were “primordial.”

Although the statement had been wrong, this led to Meech to realize that the answer to the origin of Earth’s water would have to be pursued from multiple disciplines. Since isotope chemistry had shown the existence of primordial helium coming from Earth’s interior, Meech hypothesized that it could also be used to search for Earth’s primordial water. Lydia Hallis, an astrobiology postdoc working with Meech, has used advanced ion-microprobe instrumentation on samples from Baffin Island to show that Earth’s primordial water may be very different from the surface oceans. “We hope to mount an expedition to get samples from Greenland, because these are known to have the best primordial helium signatures,” said Meech.

**Inner Solar System Material Stored in the Outer Solar System**

The European Space Agency’s Rosetta mission, along with many ground-based measurements have shown that cometary D/H has a wide range of values. The relative amount of deuterium to hydrogen is temperature dependent and set during formation of the comet’s ices. The widely ranging values seen in comets suggests that they formed over a wide range of temperatures (distances from the Sun) in the Solar System.

On September 22, 2014 the Pan-STARRS1 telescope discovered a very weak active long period comet (LPC), C/2014 S3 near its closest approach to the sun. This was very unusual since LPCs usually develop long tails as their ices heat up for the first time. Dubbed a “Manx” comet for its nearly tailless appearance (like the cat), a spectrum showed that its composition was similar to inner solar system rocky material—very different from the red organic-rich surfaces of comets.

Astronomers have many models of how planets in Solar System grew, some have the planets forming in place, while others have large scale gas giant planet migration. All of the small leftovers, the rocky or icy-planetesimals were scattered by the giant planets. From where in the solar system material gets scattered into the Earth-building zone depends on which model is correct.

“This discovery of a Manx with inner solar system composition was really exciting,” said Meech. “Because this is only consistent with some of the models, Manx comets may provide a way to discriminate between formation models.”

**The Proteus Mission — Searching for Origins**

The large variation in D/H in comets coupled with large scale movement of these icy leftovers of the planet building process show that astronomers cannot use a single chemical fingerprint to trace the delivery of water to the inner solar system. Measurements of other protoplanetary disks and models show that multiple chemical and isotopic signatures should be frozen onto the planetary building blocks.

Tracing different chemicals can provide independent measurements of where the material originated. To access this record, astronomers need: (1) a population of icy bodies that faithfully records the history of volatile migration in the early solar system; (2) a source of volatiles that can be accessed affordably; (3) knowledge that the volatiles were not altered by heating in their parent body; and (4) measurements from multiple chemical markers with sufficient precision to distinguish between original volatile reservoirs. Main Belt Comets (MBCs), a class of icy bodies that orbit within the asteroid belt that were discovered by astronomers in Hawai’i, meet
these requirements.

MBCs are the perfect targets for this investigation because they satisfy these criteria. MBCs have emerged as significant reservoirs of primordial water and potentially other volatiles. These icy asteroids may have formed in-situ or been dynamically implanted as the giant planets grew. Unlike true comets, they have remained on stable orbits since the era of planet formation or migration and preserve a record of their accretional or growth environment, frozen in time. Occasionally an MBC gets hit by a meter-scale impactor that strips away part of its insulating regolith (loose covering). The newly exposed volatiles sublime into space over an extended period. “Unlike asteroids, the ISO, 1I/’Oumuamua. In spite of a very short period of visibility there was an intense observing frenzy to characterize it that has led to the publication of more than 120 papers.

"ISOs are the leftover debris from the process of building planets in other star systems," said Meech. "When they are delivered to our neighborhood, ISOs give us a close up view of the planet building processes elsewhere that we cannot get any other way."

‘Oumuamua has challenged many assumptions by astronomers about what small bodies from another star system would look like, tight-lipped witnesses to events in the early solar system, MBCs are extroverts; spewing their secrets into space where a nearby spacecraft can observe them without having to land and excavate," said Meech.

A team of scientists from the IfA and the School of Ocean and Earth Science and Technology at UH Mānoa, NASA’s Jet Propulsion Laboratory, the Southwest Research Institute, and the Japan Aerospace Exploration Agency are developing a Discovery-class mission concept called Proteus to explore multiple MBCs. Proteus will provide key missing information about the processes that created a habitable planet in Earth’s Solar System.

Interstellar Objects — Messengers from other Star Systems
On October 19, 2017, the Pan-STARRS1 telescope discovered the first interstellar object because its elongated shape was atypical of a comet. Currently, UH researchers are intensely studying a new interstellar remnant, 2I/Borisov, that will remain visible for over a year. With the Vera C. Rubin Observatory, formerly known as the Large Synoptic Survey Telescope, scheduled to come on line soon in Chile, astronomers from around the world can expect to see an increase in the number of ISOs discovered. This will provide astronomers with more samples of materials from other star systems to compare with the primordial building blocks of Earth’s Solar System — helping to further address the question surrounding the formation of habitable worlds.

“The next question of whether or not they are inhabited is still off in the future,” added Meech.

“Unlike asteroids, the tight-lipped witnesses to events in the early solar system, MBCs are extroverts; spewing their secrets into space where a nearby spacecraft can observe them without having to land and excavate.”

— KAREN MEECH, Astrobiologist

Facing page: Artist’s impression of the probable history of C/2014 S3 through the inner and outer solar system over 4.5 billion years. CREDIT: ESO/L. CALCADA


RIGHT: ‘Oumuamua, the first interstellar object discovered by UH’s Pan-STARRS1 telescope on October 19, 2017
HI STAR Program Garners High-Five Results

For more than a decade, IfA’s Hawai‘i Student Teacher Astronomy Research (HI STAR) program has attracted highly motivated middle and high school students from across the state interested in learning the skills and techniques of astronomical research using real data. Funding for the program is provided by the Maui Economic Development Board, U.S. Air Force and the THINK Fund at the Hawai‘i Community Foundation.

“The HI STAR program introduces Hawai‘i students across the islands to the basic practices of science,” said HI STAR Director J.D. Armstrong, who also serves as director of outreach at IfA Maui. “Science is about exploration, discovery and helping humankind to better understand the universe.”

The program begins in a classroom setting with students attending a week-long summer program held at either UH Mānoa or UH Maui College, which feature hands-on projects and lectures given by leading experts in the field, including many researchers from IfA. For the remainder of the year, the program changes into a research group covering a broad range of astronomical topics, including helioseismology (study of the Sun’s structure through its oscillations), Near Earth Objects (NEOs), quasars, comets, exoplanets, star evolution, gravitational lensing (when a large mass creates a gravitational field that distorts and magnifies light allowing the study of early galaxies too distant to be seen with current telescope technology) and Modified Newtonian Dynamics (an alternative explanation to dark matter).

The HI STAR students lead their own research with the guidance of a mentor, to model the real-world responsibilities of scientists, including the importance of disseminating information about their research. As a result, students are encouraged to participate in local science and engineering fairs and to treat it as a scientific conference — focusing primarily on their science and communication skills, not so much the competition. Despite this unique approach, HI STAR students have racked up numerous awards, with an average of about two students making it to the International Science and Engineering Fair (ISEF) each year.

Zach Teagarden of Maui High School was awarded first place for the U.S. Air Force Research Lab award on the subject of physics and electronics at the New Hampshire Science and Engineering Fair, which was held virtually this past March. His project titled, “MOND over Dark Matter,” utilized data from the Las Cumbres and Pan-STARRS observatories to test the theory of Modified Newtonian Dynamics. Teagarden attended the HI STAR program in 2018 and 2019. His younger brother Jed, who is also a HI STAR scholar and an eighth grader at Montessori School of Maui, received the top Junior Award at the 2020 Maui County Regional Science and Engineering Fair in February and took second in the physics and astronomy junior division category at the Hawai‘i State Science & Engineering Fair.

Then this past April, Luke Berrigan from King Kekaulike High School on the island of Maui, received second place for the Best in Category for Physics and Astronomy at the 2020 Hawai‘i State Science and Engineering Fair for his research titled, “Investigating the Source of ‘Oumuamua,” which was the first interstellar object detected by IfA researchers at UH’s Pan-STARRS telescope in 2017. Berrigan joined the HI STAR program as a ninth-grader in 2018.

“I hope to follow a scientific path and become some sort of scientist,” said Berrigan, who will be a junior next year. “Space has always fascinated me, so the long term goal is to be an astronaut.”
The HI STAR students lead their own research with the guidance of a mentor, to model the real-world responsibilities of scientists, including the importance of disseminating information about their research.

Perhaps more important than the research, is the effect on a student’s future. As legendary astronomer George Herbig said of the program in 2009, “What you are doing is important. This is where the next generation of scientists will come from.”

Many HI STAR students have been offered admission to prestigious schools such as Harvard, Caltech, Princeton, MIT and Yale. After graduating from college, some of the students have chosen to continue on to graduate school and pursue careers in the sciences. Two recent HI STAR students are in graduate school working toward their Phds in fields related to astronomy, while two others have been offered admission into several PhD programs for the fall of 2020, including UH’s Institute for Astronomy. Over the years, HI STAR alumni have received almost half a million dollars in prize fellowships and stipends.

Now in its fourteenth year, the HI STAR program has seen over 200 participants come through its doors, created in 2007 by former high school physics teacher Mary Kadooka, UH Mānoa Physics and Astronomy Instructor Michael Nassir, and IfA Astronomer Karen Meech. Program team members are comprised of IfA staff, faculty and graduate students from Maui, O’ahu and Hilo, with HI STAR alumni participating as program support. Currently assisting Armstrong with the program are IfA Education/Outreach Specialist Carolyn Kaichi, UH Maui College Astronomy Instructor Jenny Hsin-Yi Shih, Robert Hubbell and amateur astronomer Donn Starkey.

“I just want to do some interesting science, and working with the students is my way of doing that. They are really more than students to me, they are collaborators,” said Armstrong. “Science should be fun, and we do have a lot of fun.”

HI STAR alumni are not only college and research ready, they are also becoming future leaders in the science, engineering and technology fields that are so important to Hawai’i and the nation.
David Michael Karl
THE MAN BEHIND THE SCIENCE

DAVID MICHAEL KARL, WORLD-RENOWED OCEANOGRAPHY PROFESSOR AT THE UNIVERSITY OF HAWAI‘I AT MĀNOA (UH MĀNOA), has contributed to some of the world’s most pivotal oceanographic discoveries, including the hydrothermal vents in the Galapagos Rift, a thriving food web in the frigid waters of Antarctica, and the development of widely adopted analytical methods to better understand ocean life and biochemistry. Most notably, he is known for helping to establish an open ocean time-series station, known as Station ALOHA, that has produced essential ocean scientific data over the past 30 years. At Station ALOHA, Karl and colleagues have provided the most convincing evidence of decreasing ocean pH (so-called “ocean acidification”), that is the result of increasing CO2 in the atmosphere (from fossil fuel burning), and its uptake into ocean waters over time.

On the other side of the ledger, Karl has been prolific in securing extramural research funding. Since joining UH Mānoa in 1978, Karl has been principal investigator on more than 80 grants bringing over $100 million in federal and foundation funds plus over $50 million additionally to support research vessels and submersibles used in his own research. In 2006, the National Science Foundation (NSF) awarded Karl and colleagues a 10-year $36.8 million grant that led to the establishment of the Daniel K. Inouye Center for Microbial Oceanography: Research and Education (C-MORE), one of only 17 NSF science and technology centers in the nation at that time. In 2014, a $48 million private foundation award created the Simons Collaboration on Ocean Processes and Ecology (SCOPE) to complement the research of HOT and C-MORE. To date, this award from the Simons Foundation, remains the largest one-time award to the University of Hawai‘i.

Befitting a distinguished career such as Karl’s, he was elected into the National Academy of Sciences in 2006, is a recipient of the Gordon and Betty Moore Foundation Investigator Award in Marine Microbiology, May 2004-2020; recipient of the 2013 Alexander Agassiz Medal from the National Academy of Sciences; and recipient of the 2015 Balzan Prize for Oceanography, to name just a few of many.

Born Leader
While all of these achievements, awards and accolades are impressive in the world of science, Karl the man shines even brighter due to his humility, generosity and kindness — traits that are not often found in scientists of his stature. C-MORE and SCOPE Co-Director Edward DeLong, a pioneering microbiologist in his own right, has known Karl for over 30 years and feels those particular traits and his ability to work collegially with diverse groups of people have made him a phenomenal science leader.

“Dave’s been able to assemble these groups of stellar people from renowned institutions like MIT, Woods Hole Oceanographic Institution, the University of California, and the Monterey Bay Aquarium Institute, to name a few. He is able to engage top scientists from around the world, and focus their energies on singular goals that none could achieve independently. The end result produces teams of scientists that can work together extremely effectively under Dave’s leadership,” said DeLong.

“People trust Dave as a leader, because they trust him as person and as a world-class scientist.”

Karl is also known to lead by example, earning the respect of everybody from the boots on the ground and up. From going out to sea and working on deck to driving a forklift on the docks, no task is too small for Karl. “He likes to work on a level playing field. There is no hierarchy. Everybody’s on the same plane,” added DeLong.

Unmatched Generosity
Oceanography Associate Professor Angelique White, who has recently taken over the reins of the HOT program, counts herself fortunate to have Karl as a mentor and colleague to call upon. She notes that a sense of generosity and community is what makes Karl unique.

“Without a doubt, he’s just there for a lot of people,” said White. “He’s the kind of guy you can send a paper to, ask for input and he will read it — making handwritten comments on anything from Oxford commas to ‘did you see this paper in 1972 on page three, column two that had a similar sentence that might help you think about the topic in a different way.’”

Another aspect of Karl that does not go unnoticed is his incredible generosity in his recognition of others and that he is always the first in line to celebrate with his team. “Who else takes their time to take their team soapbox racing or charters a pirate ship to celebrate the accomplishment and service of their employees?,” said HOT Field and Lab Manager Eric Grabowski, who has worked closely with Karl for over 20 years and has also developed personally and professionally under him.

“While managing people, Dave seems to be keenly aware of the importance of dealing with the human side of life and not just the scientific.”

Although much of his team’s success falls on his shoulders, Karl is always quick to note that the accomplishment of the team could not happen without each individual. “Science is a team sport I always like to remind everybody of that,” said Karl. “I have the best team in the world. Things that get done are because of the people. As we say in Hawai‘i, it’s an ohana (family). Every lab group is an ohana and collectively we’re a larger ohana.”
70th Birthday Celebration

To celebrate David Karl’s 70th birthday, colleagues and friends planned on hosting an international science symposium in Honolulu in May 2020. The multi-day event would bring together former and current colleagues, researchers and students—all of whose lives and careers have been enriched in a multitude of ways because of their association and friendship with Karl. However, due to the COVID-19 outbreak, event organizers decided to pivot from the symposium to a virtual birthday celebration. Over 100 colleagues, friends and family joined on May 8, 2020 for two and a half hours of recollections and tributes to Karl—including his sister Beverly Keil, a retired vice president with the Washington Post Company; his brother Tom Karl, a retired cardiac surgeon; and his cousin Debbie Robertson, a professor of marine biology at Clark University.

“Dave has sustained a major scientific program that helped UH Mānoa rise and put it on the map on all matters relating to the ocean. What is really special, is that he is truly a homegrown treasure for UH.”
—DAVID LASSNER, UH President

“Whether you are a friend, college student or collaborator, you know you can reach out and trust his wisdom and words. I’ve been fortunate to be able to give back to a man who has given so much to UH by working closely with Dave to make C-MORE a reality. The building doesn’t make Dave Karl; Dave Karl makes the building.”
—VASSILIS L. SYR莫斯, UH Vice President for Research and Innovation

“Senator Daniel Inouye was immensely proud of Dave and this place (C-MORE Hale) he opened. He was proud because it was not an earmark. Proud of what one of the sons of UH produced in-house and he didn’t have to provide his political muscle to make it happen.”
—BRIAN TAYLOR, SOEST Dean, UH Mānoa

“You can see in his eyes that he loves to talk science. I used to enjoy talking to him as student and now my students talk to him. We all benefit from whatever interaction we can have with Dave. If we can just get a little piece of that knowledge that he carries inside of him, we’re all much better for it.”
—CHRIS SABINE, Interim Associate Dean for Research, SOEST, UH Mānoa

FACING PAGE: Karl on board the RV Kilo Moana after the successful HOT 300 expedition, February 2018. CREDIT: RYAN TABATA

TOP, LEFT: Karl in his new 120 sq. foot lab in the HiG building, March 1978. CREDIT: CHRIS WINN

TOP, RIGHT: Karl in front of the Hale ALOHA mooring buoy on the RV Moana Wave during its inaugural deployment in 1997.

MIDDLE: Karl in the lab. CREDIT: UH

BOTTOM, LEFT: Karl and his CARBON (this was the license plate) cycle at Makapuu Point, circa 2005. CREDIT: T. R. KARL

BOTTOM, RIGHT: Angelique White and David Karl at the HOT leadership transition, August 2019. ceremony. CREDIT: RYAN TABATA
THE UNIVERSITY OF HAWAI’I (UH) IS A WORLD-RENOWED HUB FOR INTERNATIONAL RESEARCH IN THE PACIFIC OCEAN.

Geographically, scientifically and operationally, the University of Hawai’i Marine Center (UH Marine Center) is the fulcrum of oceanographic research expeditions to investigate deep sea volcanic activity, open ocean microbes critical to our planet’s health, the diverse and thriving communities of the Papahanaumokuakea Marine National Monument, and more.

Since the 1970’s the UH Marine Center operated from Pier 45, often called Snug Harbor. As part of the State of Hawai’i Department of Transportation’s (HDOT) Harbors Modernization Plan to increase container terminal space at the state’s busiest commercial harbor, the UH Marine Center operations were moved to Pier 35 in 2016. A $17-million HDOT Harbors Division renovation project of the facility provided 800 feet of pier space to service up to three ships, new office and laboratory facilities, and additional warehouse and outside storage space for containers and weatherproof equipment. After moving into the new facility, UH made additional improvements and integrated the facility into the University of Hawai’i at Mānoa (UH Mānoa) campus IT infrastructure. The combined upgrades will serve the UH Marine Center well over the next several decades and help ensure that it will continue to support state-of-the-art research.

“The foremost responsibility of the UH Marine Center,” said Anita L. Lopez, director of Research Vessel Operations, “is to support the R/V Kilo Moana, a 186-foot U.S. Navy-owned research vessel that UH operates under a charter party agreement with the Office of Naval Research.”

Since it arrived in Honolulu in 2002, the R/V Kilo Moana has conducted oceanographic research throughout the Pacific Basin and averages about 220 days at sea each year. The ship is equipped to conduct physical, biological and chemical oceanography, as well as geological investigations of the seafloor and geophysical sensing of the Earth’s structure beneath.

Ocean robotics and submersible technology are pushing the frontiers of discovery. The UH remotely operated vehicle (ROV) Lu‘ukai is a small work-class ROV that can be operated from the R/V Kilo Moana to conduct investigations in waters up to 6,000 meters deep. After beginning operations in early 2018, the Lu‘ukai has supported a study of deep-sea biodiversity and ecological processes in the western Clarion-Clipperton Zone, an area where numerous manganese nodule mining exploration claims are located; has maintained and upgraded sensors at the ALOHA Cabled Observatory, the world’s deepest operating ocean observatory; and has recovered a failed telecommunications cable used to support acoustic research in local waters.

Additionally, the UH Marine Center directly supports research through available on-site, shore-side laboratories. The Center for Microbial Oceanography: Research and Education team maintains a small fleet of autonomous underwater and surface vehicles and occupies several laboratories to processes samples, including those collected through the Hawai’i Ocean Time-series, a 30-year monitoring and research program that provides an unprecedented view of the key role microbes play in the health of the oceans and atmosphere.

The UH Marine Center also hosts other research vessels operating in the Central Pacific, especially those in the U.S. Academic Research Fleet, as well as those operated by a number of private philanthropies. These host-ed vessels bring along their crew members, equipment and scientists, providing UH with expanded expeditionary and scientific opportunities and collaborations.

Sustainability and stewardship

In addition to supporting environmental research, the UH Marine Center strives to be a responsible environmental steward. In 2018, 542 photovoltaic panels and batteries were installed with the goal of reducing the Center’s yearly electricity bill of about $75,000. The project, which includes data monitoring and analysis equipment and technology, was completed in collaboration with the Hawai’i Natural Energy Institute (HNEI), a research institute within the UH Mānoa School of Ocean and Earth Science and Technology. The excess
energy output from the HNEIPV system will also feed the overall UH Marine Center, contributing to UH and the state of Hawai‘i’s energy goal to become net zero by the year 2035. HNEI also leads GridSTART (Grid System Technologies Advanced Research Team) which is focused on the integration and analysis of energy technologies and power systems, including smart grid and micro grid applications.

That same year, Ross Barnes, marine operations superintendent of the UH Marine Center, was honored by HDOT Harbors Division as Tenant Environmental Manager of the Year. The DOT annual award recognizes exemplary environmental and safety practices, in addition to continued efforts to implement and maintain post-construction best management practices. Barnes recently retired in March 2020, after 41 years of dedicated and exemplary service to UH.

End of an era, looking ahead to the future

In late 2019, the 223-foot R/V Ka‘imikai-O-Kanaloa was retired from service. Affectionately known to many as the K-O-K, the ship joined the fleet of UH marine expeditionary research vessels on January 15, 1994. Since then, K-O-K was used extensively across the Pacific Ocean on a variety of missions that included submersible operations, deployment of deep-sea moorings, hydrographic surveys and studies of marine biology, chemistry and climate change.

“The University of Hawai‘i is best positioned regionally to provide research vessel services to federal, state and private entities without having the carbon footprint impacts of repositioning like vessels from the east or west coast.”

–ANITA LOPEZ, Director of Research Vessel Operations

A leader focused on supporting science and society

Prior to joining the UH Marine Center two years ago, Lopez was the deputy director of Operations at the Office of Marine and Aviation Operations and deputy director of the NOAA Commissioned Officer Corps for the National Oceanic and Atmospheric Administration (NOAA). She was responsible for the operations of NOAA’s nine aircraft and sixteen research vessel fleet and approximately 1,000 employees operating across the country. A seasoned mariner, she has had over nine years of underway shipboard bridge experience and sailed as captain of the NOAA Ship Oscar Elton Sette, a fisheries research vessel homeported at Joint Base Pearl Harbor-Hickam.

In her leadership role at the UH Marine Center, Lopez is focusing on providing world-class support and services to mission partners, meeting all research mission objectives, investing in her team, and ensuring operations are conducted safely and efficiently. “We have an amazing team of professional mariners, technicians, and administrative staff that love what they do and enjoy being part of contributing to the learning of our environment and ensuring the sustainability of our natural resources,” said Lopez.

Her experiences working in Hawaiian waters, including the Papahanaumokuakea Marine National Monument, and sharing the opportunities of research and science with local children inspired her to return to Hawai‘i to contribute to the education of the state’s youth, as well as provide world-class research vessel services for the research community.

“I am thrilled about returning to Hawai‘i and excited about being a part of the many services we provide for the research community and the state,” she added.
3D Scanning for Better Health on Earth and Possibly... in Space

“MAGIC MIRROR ON THE WALL, WHO’S THE FAIREST OF THEM ALL?” is the famous question posed by the Evil Queen to her talking mirror in Disney’s fairy tale Snow White and the Seven Dwarfs. While the vain Evil Queen may have not liked all of its replies, people may want the truth from their mirrors—as these or other devices may soon be able to accurately assess a person’s health through the image it sees.

At the forefront of this research is John Shepherd, an epidemiology researcher at the University of Hawai‘i Cancer Center (UH Cancer Center), who along with his team, are leading the development of novel tools and techniques to derive clinical health information obtained by 3D body scanners through the Shape Up! Study funded by the National Institutes of Health.

“Human body shape is an intuitive marker of health,” said Shepherd. “We envision that monitoring body shape when exercising, or changing your diet gives you more useful feedback than change in weight on a scale, and will help people be more successful with their lifestyle changes, live healthier and live longer.”

Under the study, full-body 3D optical scans of 720 adults and 720 children are being taken at high spatial resolution to explore and develop ways to measure health and body composition from the images. These technologies take a look inside areas of the human body hidden by skin and bones. Researchers will test if new imaging machines can provide useful and detailed information about various health and wellness risks.

“With these data, we can do some amazing things including modeling body shape changes due to loss or gain of muscle and fat,” said Shepherd, who serves as principal investigator of the study, that also includes the University of Washington Computer Science Department, Louisiana State University’s Pennington Biomedical Research Center and the University of California at San Francisco. “The findings from these studies will empower researchers, clinicians, and even consumers to measure and monitor their body shape and health.”

The Modern Era of Machine Learning/Artificial Intelligence (AI)

“There are strong signatures in our body shape that is related to things we’ve done in the past, how we eat, our exercise levels and also our risk factors for cancer,” said Shepherd. “What my work does is to bring that into the modern era of machine learning.”

For decades, simple metrics such as waist circumference and hip circumference have been used by the medical profession as powerful predictors of cardiovascular disease and diabetes—using a single hypothesis. Shepherd’s research takes this to the next level by incorporating machine learning to characterize how one person’s body differs from their peers in fine detail, down to the millimeter, and looks into multiple hypotheses of related cancer risks or other medical conditions associated with the variation. “That’s very different than saying I have a specific measurement for this condition or for that condition,” added Shepherd.

The research conducted by Shepherd and this team could lead to other advances in the near future, including a realistic “magic mirror” in the home. For example, by comparing images taken daily by a 3D optical scanner, it is possible for the mirror to passively detect subtle body changes like an increase in face or neck width, or even an increase in body size. If a certain established threshold is crossed, the mirror might suggest to the individual about the possible risk of high blood pressure and that their pressure should be checked through an attached cuff. The pressure reading is then tied to the observable change and catalogued for future assessments. If subsequent readings indicate that the person is on a bad pathway, either a note to contact a physician could be generated or a direct notification to a physician could be sent.

Applications of 3D Scans in Space

While Shepherd’s research is very important on terra firma, the National Aeronautics and Space Administration (NASA) is looking to harness this type of technology for its future planned missions to the Moon and eventually Mars—and they’ve turned to Shepherd and his team at the UH Cancer Center to assist.

On long-duration space flights, musculoskeletal changes primarily from acclimation to a microgravity environment can cause a loss of over 30 percent of muscle mass in less than six months. Astronauts on long-duration space flights share frailty characteristics of sarcopenia, cachexia and even osteoporosis, increasing the risk of bone fractures and loss of function—conditions that would endanger crew safety and put missions in jeopardy. The
most intuitive warning sign of this functional decline is physical changes in appearance or body shape.

Due to his research expertise in body composition and shape analysis, NASA’s Translation Research Institute for Space Health awarded a grant to Shepherd’s ASTRO3DD study that was designed to measure body composition on long-duration space flights. Shepherd and this team will monitor frailty risk using 3D whole body optical scans and create a space-feasible prototype for microgravity testing.

“Because astronauts lose muscle mass from the effects of microgravity, they need to be able to have direct feedback on the quality of their muscles and bones in flight,” said Shepherd. “With the technology our team develops, we hope the astronauts can modify their nutrition and adjust their training to minimize the expected muscle loss.”

While current 3D optical scan models can accurately estimate bone and body composition on Earth, they are not acclimated for space. Due to microgravity, extracellular fluids in the body tend to redistribute around the body depending on body position leading to changes in body shape. Part of the team’s research is to monitor frailty risks using 3D scans with the necessary adjustments to compensate for the fluid redistribution.

A New Area in Cancer Research

Measurement of body composition is a relatively new area in cancer research that has direct implications for understanding how obesity and body shape contribute to the development of cancer and its outcomes.

“This research is incredibly novel as it will lead to the development of new methods for measuring body composition for astronauts in space who are prone to muscle and bone loss, but it also has direct applications to cancer patients who may suffer from a similar condition called cancer cachexia,” said UH Cancer Center Director Randall Holcombe.

“the research findings by dr. Shepherd and his team may eventually be utilized to better understand and prevent cancer-related muscle wasting and improve the quality of life for cancer patients.”

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“This research is incredibly novel as it will lead to the development of new methods for measuring body composition for astronauts in space who are prone to muscle and bone loss, but it also has direct applications to cancer patients who may suffer from a similar condition called cancer cachexia.”

RANDALL HOLCOMBE, UH Cancer Center Director

Facing page:
Dr. John Shepherd and his team

Left: Dr. Shepherd explains the BodPod procedure to a subject while a lab staffer sets up the subject profile.

Right, top: Dr. Shepherd scans a subject on a dual energy x-ray absorptiometry (DXA) system.

Right, bottom: Sample of a full-body optical 3D scan

CREDIT: UH CANCeR CeNteR
Iconic Watercress Farm Aids UH Sustainability Research

ONCE A PREFERRED SWIMMING POOL OF HAWAIIAN ALI'I, the Kalauao Spring on the island of O'ahu today continues to supply millions of gallons of clean, fresh water to the Pearl Harbor region. But changes to the environment, climate and continued development of the surrounding areas has put into question its sustainability. A unique partnership between the multigenerational Sumida Farm family and researchers from the University of Hawai'i at Mānoa (UH Mānoa) is using novel methods to study the past, present and future of this fragile resource.

Since 1928 when Makiyo and Moriichi Sumida started watercress farming near Kalauao Spring, the Pearl Harbor area has transitioned from small family farms, to plantation agriculture, to today's densely urban landscape that includes the Pearl Ridge Shopping Center, military installations, condominiums, strip malls and now, the Honolulu Rail Transit System. Throughout these changes, the Sumidas' 11 acres of bright green watercress fields have been cultivated in much the same way as they were more than 90 years ago — hand-planted, hand-harvested, and hand-washed to weekly produce four to five tons of the nutritious traditional crop that O'ahu's families and chefs have loved for generations. Sumida Farm supplies 70 percent of the state's watercress, and is one of only a handful of watercress farms remaining in Hawai'i.

In 2017, the Sumida family began to collaborate with members of UH Mānoa's 'Ike Wai (Agriculture, Sustainability, Planning, and Engagement) research group to investigate changes they were observing in their crops. Third-generation siblings Barbara and David Sumida had been running the farm for decades, and had seen their share of challenges, including invasions of the diamondback moth and aster yellows disease. But now, they were starting to wonder about the clean fresh spring water that was the source of their livelihood. Was it experiencing pollution from the surrounding urban development? Were the springs getting saltier from sea level rise? Why were the crops dying off during the hottest summer months?

Funding secured by Hawai'i Institute of Geophysics and Planetology affiliate Jennifer Engels from an Active Societal Participation in Research and Education (ASPIRe) grant, and 'Ike Wai, allowed a multi-disciplinary team of UH Mānoa researchers to work side by side with the Sumida family to discover the past, present and future sustainability of their water resource using a mixed-methods approach.

"This deep dive into the history of the farm uncovered some very surprising insights," said Engels. "The close partnership between the UH Mānoa team and the Sumidas resulted in a great synergy of ideas and information that would never have been possible without their generational accounts of lived experiences on the farm."

Barbara Sumida kept detailed hand-written records of watercress yields over the years—bundles harvested, sales prices, delivery locations and notes regarding weather conditions, pest infestations and fertilizing schedules. This treasure trove of time-series data about the crop history formed the basis of a 25-year retrospective trend analysis conducted by University of Hawai'i Economic Research Organization (UHERO) Economists Kimberly Burnett and Christopher Wada, along with economics graduate student Nate DeMaagd, that compared harvest data to factors such as groundwater pumping, rainfall, air temperature and the Oceanic Niño Index (ONI). As expected, watercress yields were negatively correlated with high temperatures, increases to the ONI and the presence of pests.

Next the UH Mānoa team worked to collect monthly water samples from spring locations across the farm—mauka (mountain), middle, and makai (ocean). Earth Sciences Professor Henrietta Dulai tested samples for the presence of chemicals that pass through the human body into cesspools, including estrogen and caffeine—that surprisingly, were below detection limits. Usually, agricultural chemicals from the plantation era tend to linger for decades, including the pesticides atrazine and DDT—however, they too were below detection limits, indicating that Kalauao Spring’s source has been geologically isolated from human pollutants. Dulai also looked for sea level rise-induced saltwater intrusion and found that the makai side of the farm is starting to show trace amounts of salt—a concerning omen for the future.

Geographer Leah Bremer of UHERO and the Water Resource Research Center and Department of Urban and Regional Studies graduate student Pi'ilani Smith interviewed the Sumida family and researched local press to get insight into the resilience of the Sumidas’ watercress farm despite the pressures of urbanization that have made other small farms obsolete around the islands. What did the Sumidas do differently? What is special about Kalauao Spring? How has the community supported and valued...
“The close partnership between the UH Mānoa team and the Sumidas resulted in a great synergy of ideas and information that would never have been possible without their generational accounts of lived experiences on the farm.”

–Jennifer Engels, HIGP Affiliate
As urban areas expand around the world, there are growing efforts to restore and protect natural and agricultural systems for the services they provide to urban communities, such as crop production, flood prevention and nutrient retention.

In an unfortunate and heartbreaking turn of events, Barbara Sumida passed away in February of this year. Although her presence is deeply missed, her spirit and legacy remain strong. Her brother David, now joined by the fourth generation of Sumida farmers, Emi and Kyle, are continuing their partnership with UH Mānoa’s research team. Their goal is to adapt and evolve the farm in response to changing environmental and social needs so they can continue to nourish the islands and serve the community. The Sumida legacy is certainly alive and well, as the family farm continues to sustain its community in more ways than one.
There was a time when computers took up an entire room, ran inefficiently and were not very user-friendly. Since then, computers have evolved into small, powerful, cost-efficient and easy to use tools that have changed our understanding of the world around us and the universe beyond. The computing power provided by the current generation of servers, laptops, tablets, smartphones and connected devices has transformed society into one that has become quite dependent on technology and the convenience it provides.

However, this convenience still requires a certain level of input from human operators to perform operations and complete tasks. Whether searching for a nearby restaurant on Google or adjusting a Nest thermostat to further cool the room, these actions must still be keyed in or programmed manually on a smartphone or smartwatch. As today’s fast-paced, high-tech world demands even more, technology is being pushed towards the seamless integration of computers into the surrounding environment through an approach known as Ambient Computing.

Ambient Computing technologies often perform computational tasks without a direct command from the user, resulting in interactions that can occur without the user’s knowledge. Amazon’s Alexa and Google Assistant are current examples of Ambient Computing devices that turn on lights, play songs or provide the weather report in response to spoken commands issued to the environment itself. As Ambient Computing progresses, technologies like motion tracking, gestures, voice recognition, artificial intelligence and others will be incorporated to achieve an increasingly seamless interplay of devices and services.

UH Mānoa’s Ambient Lab

Shaping the future of interactive computing

Carlson’s IoT course provides each student with Raspberry Pi computers.
ambient computer lab projects

ambient computing technologies often perform computational tasks without a direct command from the user, resulting in interactions that can occur without the user’s knowledge.

the ambient computing laboratory at the university of hawaii at manoa’s college of engineering develops advanced cyber-physical systems that combine interactive multimedia with the unique research possibilities offered by the billions of connected devices that are increasingly connected to the internet. this evolution of the internet, known as the internet of things (iot), is well underway, with the current 20 billion connected devices projected to surpass 75 billion devices by the year 2025.

“our students develop novel algorithms, frameworks and approaches for building iot ‘smart spaces’ that will power next-generation computing environments,” said electrical engineering assistant professor darren carlson, the cyber-physical systems expert who founded and directs the ambient lab. “these environments are physical locations infused with sensors, embedded computers and intelligently coordinated network services that provide users with digitally augmented experiences that are responsive, adaptive and personalized.”

the ambient lab’s research focuses on several hawaii-specific needs, such as remote collaboration, distance education and connected healthcare. together with uh system’s academy for creative media (acm system), the lab also helps foster uh’s emerging computational media study program, which trains students and working professionals in the areas of video game development, virtual and augmented reality, and digital storytelling and filmmaking.

“These new forms of digital content are causing seismic shifts in media consumption habits and consumer behavior worldwide,” said carlson. “incredibly, the video game and interactive media industries are estimated to surpass $300 billion in global revenue by 2025—dwarfing mainstream entertainment sectors, such as television, music, and film.”

recognizing the strategic value of this ongoing digital transformation, acm system’s founder and director, chris lee, has spent over fifteen years developing hawaii as a center of excellence in media. lee, who previously served as president of production for both tristar pictures and columbia pictures, established acm system in 2003 to promote integrated multimedia, arts, and technology education in hawaii as a catalyst for creating 21st century knowledge-based jobs across the islands. lee has been instrumental raising the public and private capital needed to fund its activities, building initiatives, and attracting visionary researchers—like carlson to uh in 2016.

“with the current industry shift toward interactive media, one of my goals is to fuse computer engineering with new forms of digital design and interactive entertainment,” said lee. “darren’s globally recognized expertise in cyber-physical systems coupled with his award-winning research track on interactive environments was an essential piece of the puzzle to help us achieve that goal.”

Carlson’s appointment complements ACM System’s ongoing support of uh professor Jason Leigh’s laboratory for advanced visualization & applications (lava) at uh manoa. since 2014, lava has served as a dynamic maker space and innovation hub at uh, where researchers develop a wide range of big data visualization techniques for science, engineering and training. lava also forms the core of the hawaii data science institute, which serves the data intensive science, engineering and training needs of uh system’s 10 campuses.

Carlson initially designed two innovative courses that incorporate engineering, computer science and design. his first course teaches students how to build smart, connected products using iot technology and cloud computing. during the semester, students form “mini start-ups” and create prototype iot systems that are presented during a simulated venture capital pitch event on the last day of class. his second course covers the advanced programming techniques used to build video games, virtual reality systems and interactive installations. this course supports uh degree programs and is also part of the uh’s upcoming creative computational media certificate, which brings together students and faculty from the ambient lab, lava, uhm animation and even uh manoa’s department of theatre and dance.

“The ambient lab’s core research area
addresses the critical fragmentation challenges that threaten the IoT’s existence as an open ecosystem,” said Carlson. “Although connected devices and network connectivity are becoming ubiquitous, a historic lack of open protocol standards and fierce competition for market dominance is rapidly fragmenting the IoT at the application layer — creating a patchwork of isolated walled gardens with limited reach.”

To unify wide-area IoT interactions, the Ambient Lab is developing an adaptive mobile computing framework, called Ambient Dynamix, which enables diverse connected devices and network services to work together across IoT ecosystem boundaries. Dynamix provides an open plug-and-play architecture that allows for the dynamic integration of new algorithms, connected device support and third-party software at runtime.

After installing Dynamix, mobile users can simply “walk up and use” almost any nearby connected device using their smartphone or tablet—regardless of its network, vendor or IoT ecosystem. As users change locations, Dynamix automatically discovers the available IoT devices and services nearby and then deploys the plug-ins needed to communicate with them over-the-air at runtime. As users interact with new physical environments, Dynamix automatically models the encountered networks, services and connected devices at scale, by transforming the growing community of Dynamix-enabled mobile clients into a distributed IoT crowd-sensing platform—aggregating the scanned results into the lab’s IoT search engine, which supports context-aware device discovery, plug-in based adaptation and service orchestration.

Building on these techniques, the Ambient Lab is also creating an advanced Smart Space framework that can be used to build a variety of digitally augmented physical environments using next-generation Edge Computing. “Edge Computing refers to a paradigm in which the resources of a small data center are strategically placed at the edge of the Internet,” said Carlson. “By offloading processor and memory intensive tasks to powerful servers situated at the network edge, connected device applications enjoy fast response times, stable bandwidth characteristics and a lower risk of connection loss.”

This new framework, called Ambient Edge, enhances traditional Edge Computing techniques with proactive service staging, plug-and-play device integration, real-time messaging, automatic task offloading and seamless handover between Smart Spaces. The Ambient Lab is also building a visual programming extension for Ambient Edge, which will enable designers without extensive programming knowledge to build a variety of immersive systems, including interactive installations, enhanced learning spaces, digitally augmented architecture and projection mapping that turns any surface into an interactive video display.

Learn more about the Ambient Lab at: http://ambientlabs.org
They all share the mantle of being some of the world’s most influential, recognizable and profitable companies. Unfortunately, they along with many other Fortune 500 companies also share a more dubious commonality—they have all been the victims of a cyberattack.

While companies have invested in robust cybersecurity protection measures, the sheer numbers of bad actors ranging from hostile foreign governments to the teenage hacker operating out of his/her bedroom—have made it increasing difficult for cybersecurity experts to stay ahead of the curve. To combat this ever growing threat, it has become paramount to educate and create a new generation of cyber-savvy students ready to enter the workforce in this critical area.

One such effort is the GenCyber Program, a national movement to increase interest in cybersecurity careers for students and teachers, while diversifying the cybersecurity workforce in the United States. The mission is simple: to ensure that enough young people are interested and inspired to direct their talents into this vital field of protecting the country’s national and economic security in an internet-connected space.

In Hawaii, the statewide effort led by the University of Hawaii in partnership with the National Security Agency (NSA), National Science Foundation (NSF), Pacific Center for Advanced Technical Training (PCATT), Hawaii Department of Education, CyberHawaii and the Maui Economic Development Board. Since 2015, the program known locally as GenCyber Hawaii, has hosted 25 student camps and 25 teacher camps that have engaged and enriched 683 K-12 students and 701 K-12 teachers from across the state.

“The GenCyber Hawaii camps are an important first introduction for students to learn about information technology and cybersecurity in a fun, hands-on and engaging learning environment,” said Jodi Ito, chief information security officer for the University of Hawaii and lead coordinator of GenCyber Hawaii. “For the teachers, it provides them with the necessary
roadmap, tools and curriculum to help them prepare their students for a potential future in this vital, high-demand field.”

Prior experience in cybersecurity is not needed to participate in GenCyber Hawai‘i and the camps are offered at no cost to participants with funding provided jointly by the NSA and the NSF. Topics include introductions to cybersecurity, how the internet works, networking, cyber forensics, computer science, and cryptography. Additionally, students learn about being a good digital citizen, cybersecurity ethics, cyber hygiene, spotting fraud and phishing attacks, and group problem solving exercises that closely simulates the teamwork often necessary as a cybersecurity analyst.

Another highlight at the GenCyber Hawai‘i camp is the mini career and education fair. This popular event allows both parents and students to learn more about cybersecurity and the different career opportunities available from local employers, such as the NSA, FBI, Hawaiian Telcom, Bank of Hawaii, CIO Council of Hawaii, University of Hawaii and others.

The one-week camp culminates with an exciting capture-the-flag type event that has participants team up to utilize their newly acquired skills to hack and defend their way to victory. Raspberry Pi, a single-board computer, is used throughout the camp to help students learn programming skills, build hardware projects, and explore how find ways to secure the Internet of Things (IoT). Each student is given a Raspberry Pi to take home.

“GenCyber Hawai‘i has allowed me to pursue my passion of cybersecurity and computer science,” said one student. “Every day I looked forward to camp because I know that I will be constantly developing my skills not only in the realm of cybersecurity, but also soft skills such as collaborating with others.”

For teachers, GenCyber Hawai‘i serves as a professional development course that enables them to provide their students with the necessary tools to become safe and responsible users of the internet. Teaching materials provided are aligned with the appropriate standards, includes lesson plans, technology starter kits, classroom project ideas, and access to a GenCyber teacher network to help with additional resources and promote collaborative efforts.

As a result, GenCyber-trained teachers are now better prepared and equipped to help students develop clear avenues to post-secondary educational opportunities and career pathways.

“Especially in this day and age I cannot stress enough the importance of the GenCyber Program for Teachers,” said Ken Kang, technology coordinator at Aiea High School and 2017 Milken Educator Award recipient. “The lessons and hands-on experiences cannot be overstated as a valuable resource for not only my students, but also for me as an educator and my practices with technology and the cyber systems around us.”

Information and registration for future GenCyber Hawai‘i camps can be accessed at https://gencyber-hi.org
Cultural Entrepreneurship in Action
KAUAI COMMUNITY COLLEGE
PUTTING THEORY INTO PRACTICE

THE DISTANCE BETWEEN KAUA‘I ISLAND, HAWAII AND THE COUNTRY OF JORDAN IS JUST OVER 8,600 MILES. While it may seem like worlds and cultures apart, students at Kaua‘i Community College (Kaua‘i CC) have managed to bridge that gap with a remarkable virtual collaboration on sustainability and entrepreneurship.

As participants in the Global Solutions Sustainability Challenge, a virtual exchange initiative that supports workforce development in the U.S., Iraq and Jordan—Kaua‘i CC international business students joined forces with their counterparts from Al-Balqua Applied University in Jordan to address the following challenge: The technology industry requires sustainable development that meets the needs of the present without compromising future generations. How can we create greater sustainability in the technology industry through the three pillars: people, planet and profit?

Team Jordwaiian, as they were aptly named, developed a pitch to address the problem of e-waste and the growing digital divide through the creation of business concept company called e-waste Not, want Not, Inc. (ewNwN). Under the plan, several for-profit divisions of the company would extract and resell precious metals in the electronics, create and sell 3D printer filament and process repurposed materials to the construction industry for building materials and road paving. Concurrently, ewNwN’s community benefits division would provide refurbished mobile phones, computers and youth-led training programs to ensure that seniors and the less-fortunate individuals have access and knowledge to stay in touch with the rapidly changing technological world.

The team advanced through the first round against 17 bi-national teams and was one of six selected to make their final pitch this past April in a virtual business exposition, placing third and receiving the audience favorite award. Although Team Jordwaiian did not win the competition, the Kaua‘i CC students were able to share with their Jordanian teammates and fellow competitors the concept of pono, the Hawaiian term of being in a state of harmony or balance with oneself, others, the land, work and life itself.

The driving force behind this group of talented and highly motivated social entrepreneurs is Assistant Professor and Business Program Coordinator Dirk Soma, who is himself, a lifelong entrepreneur in the fields of hospitality, economic development, education and career planning. Soma lives his life by the motto, “In life it’s not what you acquire, it’s who you inspire.”

The true iteration of cultural entrepreneurship came to him when he asked to review a white paper on benefits corporations and the premise to achieve the 3Ps. “I realized there was a fourth P missing—it was pono,” said Soma, who is of Native Hawaiian ancestry. “For me, cultural entrepreneurship has to incorporate preserving and perpetuating a set of values, norms and practices of a distinct community and/or place—whether it’s Kaua‘i, Jordan or someplace in between.”

By incorporating the value of pono into the standard 3P sustainable business model of planet, people and profit used by benefits corporations, Soma’s tweak to create a 4P model closely aligns it with the ancient Hawaiian land management system known as the Ahupua‘a, a system of land division that runs from the mountains to the sea, that created an equitable, self-sustaining ecosystem for each ruling chief. As a result, the existing business model canvas was transformed into the Kānaka (Native Hawaiian) Kanvas (see graphic).

“One of the great things about the Kānaka Kanvas is that it allows for flexibility and creativity, which is what we need in our startup ecosystem,” said Soma. “The creation of Kānaka Kanvas has helped our students to think outside the box and to take a deeper look at the great resources we have on island and in our state.”

As a result, a small but important startup ecosystem is beginning to take root in this sleepy island community of just over 71,000 residents—one that has recognized that it must develop a diversified and sustainable economy to weather tourism fluctuations,
including the September 2001 terrorist attacks and the current COVID-19 pandemic, to ensure that there are sufficient jobs at living wages to prevent its youth from leaving to pursue opportunities elsewhere.

The following highlight some of the recent accomplishments and national entrepreneurial awards earned by Soma’s program and students:

**HI Joe!**

Introduced in the fall 2019 semester, students from Soma’s entrepreneurial classes worked together to create a pop-up coffee tent at the Kaua’i Community Famer’s Market to provide only 100 percent Hawai’i grown and roasted coffees that will perpetuate sustainability and provide incremental income to local coffee producers. Biodegradable coffee cups, lids and stirrers are used and all coffee grounds are added to the campus compost bins. Students staffed one of three teams that included — Marketing and Promotions, Operations and Logistics, and Finance and Accounting.

“Professor Soma was great to come up with this idea of business, because it was relatively simple to start, had all the difficulties of a business and we were able to learn a lot, practicing what we learned in class,” said student Anna Lammotte. “It also showed us the need that Kaua’i has for more entrepreneurs and small businesses, as people want to be able to spend their money in great products and experiences.”

Success has come rapidly to the startup, as the Farmer’s market wants HI Joe! to be a regular vendor, Kaua’i CC has asked them to consider an on-campus kiosk, team members are considering a brick and mortar location in a shopping mall, and Intuit Education has express interest in rolling out a hands-on HI Joe! component to their financial management curriculum project to give students across the nation access to this experiential learning opportunity.

**Alaka’i Initiative**

As participants in the Student Entrepreneurship Challenge: Solutions for a Sustainable Life competition sponsored by HP Life last October, students were tasked with providing a solution to a local challenge faced around the UN Sustainability Goal 14 — Providing Quality Education. With their proposal to provide free housing for up to two years at Kaua’i hotels and condos as an incentive to help recruit and retain local teachers, students Meagan Luoma and Meghann Matsuda-Blaylock from Soma’s marketing class captured second place and the audience favorite award at the National Association for Community College Entrepreneurship (NACCE) national conference.

“This was an innovative and out-of-the-box solution to reduce the main barrier [high cost of housing] to keeping our teaching talent home,” said Soma. “By utilizing existing lodging inventory on island, this plan could be rapidly deployed and just as rapidly, make an immediate impact in both the classroom and in the community.”

Remarkably, six student teams from Soma’s class entered the competition and all six teams made it to the top 20, with the team of Luoma and Matsuda-Blaylock making it to the final five.

**Ratcliffe Pitch for the Trades**

At the same NACCE conference, Kaua’i CC’s Sustainable Building Construction Technology proposal was awarded $15,000 from the Philip E. and Carole R. Ratcliffe Foundation as part of another nation-wide contest, the 2019 Pitch Competition for the Trades.

Developed by Soma, Kaua’i CC Trades Division Chair Gordon Talbo and Carpentry Program Instructor Duke Lang, their “Back 40” Smart & Sustainable Community (B40 S&SC) proposal created a model for a sustainable community using smart technologies and indigenous knowledge that can be replicated locally, nationally and globally.

In addition to focusing on exposing students and existing tradesmen to new construction techniques focusing on sustainability, Kaua’i CC’s project also incorporates entrepreneurship skill sets to enable students to become business owners. The project envisions using a 40-acre portion of the campus to allow students to design and develop a community that incorporates sustainability in every stage from building materials, to renewable energy, aquaponics and a zero-waste management program.

One of the competition judges has already reached out to link Kaua’i CC’s project with international partner and in January of this year, Kaua’i CC received $16,000.00 for the project from a donor on the island.

“Dirk Soma and his students have really put together quite an amazing cultural entrepreneurship program that emphasizes the importance of incorporating a sense of place and local values to increase its relevancy and connection to the community,” said Kaua’i CC Chancellor Joseph Daisy. “The awards, accolades and attention that the entrepreneurship program has recently garnered is a source of great pride for our campus, our island and the state.”

**“For me, cultural entrepreneurship has to incorporate preserving and perpetuating a set of values, norms and practices of a distinct community and/or place — whether it’s Kaua’i, Jordan or someplace in between.”**

—DIRRK SOMA, Assistant Professor, Kaua’i CC

**LEFT:** The Kanaka Canvas® created by Dirk Soma serves as a platform to teach entrepreneurship.
Harnessing Algae for Natural Color and Sustenance

IN THE SEAFOOD SECTION OF TODAY’S SUPERMARKETS, consumers are treated to brightly lit refrigerated showcases filled with colorful salmon, trout, sea bass, red snapper and shellfish. For the modern seafood shopper, fish color is an important indicator of its quality and freshness.

Despite language of “color added” being mandated on labels by the US Department of Agriculture, most consumers are unaware of the fact that synthetic color is often added by feed manufacturers to aquafeeds in order to mimic the pink of wild catch. Farmed salmon is a classic example, for without the added color, it is gray.

The group of chemical compounds responsible for seafood pigmentation is known as xanthophyll carotenoids, and includes astaxanthin, lutein and canthaxanthin; the primary one is astaxanthin (pronounced “asta-ZAN-thin”). With the exception of organic seafood, the astaxanthin in farmed food is predominantly synthetic, a relatively inexpensive petrochemical made to substitute for natural astaxanthin found in microalgae and other organisms in the food chain.

Until now, natural colorant has been scarce and expensive. Demand for natural astaxanthin is high, but is cost-prohibitive with legacy microalgae production technology. That is changing with Kuehnhle AgroSystems (KAS), whose groundbreaking algae-growth technology is positioning the company to become a product leader for natural algal ingredients, including astaxanthin in a variety of markets.

Hawaiian microalgae naturally possess exceptional concentrations of protective, pigmented antioxidants to combat the sun’s harsh rays, and these are coaxed out using KAS technologies. However, microalgae have been dependent on sunlight-driven photosynthesis in order to grow, which makes it difficult to produce the very large volumes needed for feed and food materials. KAS discovered how to nurture algae to grow efficiently in total darkness and to quickly produce high amounts energy and nutrition compounds along with useful carotenoids. This method allows the algae to be grown fermentation-style, indoors in food-grade stainless steel tanks similar to beer vats in breweries.

In this way, KAS practices “vertical farming” for scalable natural products with sustainable water and land use. The algae achieve remarkably high densities in the tanks, drastically reducing their water footprint. Producing natural whole-cell nutrition from algae grown in the dark is the company’s forte, with patents pending. Significantly, the KAS technology substantially improves the unit economics to a point where natural algae can replace synthetic or unsustainable ingredients in foods and other products.

Kuehnhle AgroSystems’ Founder, Heidi Kuehnhle, PhD, is highly experienced in natural color. While a professor in the College of Tropical Agriculture and Human Resources at the University of Hawai‘i at Mānoa, her lab’s research for over 20 years focused on flower color among orchids and anthuriums. Her research, which has resulted in over 80 publications including two co-authored books, led Kuehnhle to study pigment biology found in single-celled organisms such as microalgae.

Pigments not only provide color, but they are a source of biologically active compounds for healthy anti-oxidants and anti-inflammatoryies delivered as dietary supplements and for...
topical use in cosmetics. For Kuehnle, the formation of a company was the next logical step in order to steer her cell technology out of the lab and towards commercial applications.

Helping in that transition is HATCH, a venture capital firm that runs the world’s first and only aquaculture accelerator program. HATCH invests in companies that provide technological solutions to industry challenges while providing better and more sustainable products. This unique program is in partnership with the Natural Energy Laboratory of Hawaii Authority (NELHA), the Hawaii Strategic Development Corporation and the University of Hawai’i’s UH Ventures, LLC.

Headquartered at the NELHA’s Hawaii Ocean Science and Technology Park in Kailua-Kona on Hawai’i Island, HATCH provides strategic advice to KAS and other startups on business and financial matters, which includes matching products to their ideal markets to maximize impact.

“The HATCH accelerator is an exciting opportunity to place Hawai’i on the global aquaculture innovation map,” said Steve Auerbach, interim director of the University of Hawai’i Office of Innovation and Commercialization. “It serves as a perfect complement to our growing suite of innovation and entrepreneurial programs designed to get game-changing UH-based research technologies like Kuehnle AgroSystems into the marketplace.”

Having completed participation at HATCH, KAS’s innovations and natural, non-GMO microalgae will be finding their way into aquafeeds and foods. In December 2019, their new ingredients were announced in the final event of the HATCH accelerator program in Singapore. While not yet in the market, their products are garnering a lot of attention from feed manufacturers and also from food supplement distributors eager to meet growing consumer demand for natural nutritional ingredients that conserve water and land resources.

KAS’s dedicated team of scientists has also succeeded in using the same fermentation process for producing a tasty protein-rich whole algae food ingredient. Unlike farming cattle or even soybeans, there is no polluting run-off and no use of pesticides. “Today’s production of protein uses up water and land at levels that threaten humanity. One ton of our algae protein uses only a fraction of water, with 100- to 1000-times less water than soy or beef, respectively, and no rainforests need to be cleared for farming”, said Kuehnle. This is shovel-ready technology to help address the need for locally-produced protein for the Islands’ food security. Armed with support from the Hawai’i Department of Agriculture and engineering design, KAS is seeking financing to build its first vertical farm.

“We could not have arrived where we are without the amazing team from HATCH,” noted Kuehnle. “This was our first experience with a business accelerator and I would encourage anyone with an entrepreneurial idea that can contribute to the vital industry of aquaculture to explore an opportunity with HATCH.”

Significantly, the KAS technology substantially improves the unit economics to a point where natural algae can replace synthetic or unsustainable ingredients in foods and other products.
While the sheer volume of its fuel capacity is impressive, it was the project’s engineering and design, considered radical and innovative at that time, which ultimately qualified the Red Hill Underground Fuel Storage Facility to being named as a National Historic Civil Engineering Landmark in 1995.

Red Hill: UH Lends its Expertise to an Engineering Marvel

Shrouded in secrecy until the late 1990s, the U.S. Navy’s Red Hill Underground Fuel Storage Facility on the island of O’ahu, Hawai‘i, could arguably be considered as one of the most innovative and unique engineering projects in the world. Located under a mountain ridge about three miles from Joint Base Pearl Harbor-Hickam, the massive facility utilized novel design and construction techniques for the 1940s era—that still remain significant in today’s modern engineering.

History
In response to the growing threat of war with Japan in the late 1930s, the Roosevelt administration authorized the construction of a top secret underground fuel storage facility in realization that above ground fuel storage tanks made easy targets for enemy air attack. Up to that point, underground fuel storage for naval bases involved the utilization of several, relatively small 20,000 gallon tanks buried in shallow trenches. By comparison, the final plans of the Red Hill Underground Fuel Storage Facility, which broke ground in December 1940 with the first tank completed in September 1942. The remaining 19 tanks were finished a year later, nine months ahead of schedule and coming in at a cost of $43 million dollars.

Outside of the Box Engineering
While the sheer volume of its fuel capacity is impressive, it was the project’s engineering and design, considered radical and innovative at that time, which ultimately qualified the Red Hill Underground Fuel Storage Facility to being named as a National Historic Civil Engineering Landmark in 1995. Here are some of those key features:

**Vertical Tanks**
By building vertical tanks in lieu of horizontally oriented ones, construction and excavation could occur simultaneously—made possible by a vertical shaft drilled through the centerline of the tank allowing excavated rock to be fanned down onto a series of conveyor belts in the lower access tunnel to be taken away for use as aggregate. This process eliminated the need for heavy equipment and a larger workforce to haul the material away, greatly reducing the cost of the project and shortening its timeline for completion. The project broke ground in December 1940 with the first tank completed in September 1942. The remaining 19 tanks were finished a year later, nine months ahead of schedule and coming in at a cost of $43 million dollars.

**Gravity-Fed Pipelines**
Since Red Hill is located at a higher elevation in relation to Joint Base Pearl Harbor-Hickam, three gravity-fed pipelines are used to carry bunker and jet fuel for ships and aircraft based there or for further distribution to U.S. Air Force, U.S. Marine Corps, U.S. Army and U.S. Coast Guard bases on the island. Powered pumps are used only to transfer fuel between tanks for routine maintenance or in case of an emergency.

**“Mined” Into the Mountain**
To compensate for the greater hydrostatic pressure found inside of a filled vertical tank than that of a horizontal tank, engineers lined the tank with ¼ inch thick steel plates and filling the gaps between the steel and rock with concrete. Since it was anticipated that the concrete would pull away from the rock as it cured, high-pressure grout was pumped into the gaps to prestress the lining to prevent cracks and permanently bind the sides of tank to the surrounding rock wall—fortifying them to withstand the pressure from within the tank and at the same time, making them almost impenetrable to attack from above.

**Ship in a Bottle**
As with any aging structure or facility, constant and vigilant maintenance efforts are needed to keep the operation in top shape. However, the Red Hill facility’s unique engineering design poses significant challenges to its upkeep. Since the back of the tanks are literally imbedded into the rock, visual scans for corrosion on the steel walls are impossible. As a result, specialty contractors on suspended scaffolding inside the tank—similar to those used by window washers, must painstakingly and methodically search for corrosion using hand-held ultrasonic scanners that would detect any thinning of the steel. Repairs are done by welding new ¼ inch patch plates over the affected areas on the inside of the tank and to ensure its integrity, undergo stringent testing. Unfortunately, a spill of 27,000 gallons of jet fuel occurred in January 2014 from a tank that was just put back on line after repairs were completed the previous month—catching the attention of public interest groups and regulators, as well as stirring public emotion—because the Red Hill facility is built over a vast aquifer that supplies a good portion of drinking water to greater Honolulu and to a section of Joint Base Pearl Harbor-Hickam.
Fortunately, the release was contained and did not permeate into the aquifer. The following year, officials from the U.S. Navy, U.S. Environmental Protection Agency, and the Hawai’i State Department of Health signed an administrative order of consent (AOC) to address the cleanup of the leak. It also required the Navy to research and evaluate methods of upgrades to the Red Hill tanks to decrease the threat of future leaks and to upgrade the tanks with the “best available technology” by 2045 or have the fuel removed and the facility shut down.

One suggestion has been repeatedly brought up is to retrofit the existing tanks with secondary containment or a double wall. While this would seem relatively simple, existing retrofitting technologies of double-wall/secondary containment were designed for shorter, above-ground tanks with significantly lower pressure, making them unsuitable for use at the Red Hill facility. Also, most tanks are not locked into a mountain, with access further restricted by a narrow walkway—making it virtually impossible to move large structures in for repairs.

“To some degree, figuring out double-wall equivalency or secondary containment here is akin to building a ship in a bottle,” said Captain Marc R. Delao, commanding officer of Naval Facilities Engineering Command Hawai’i. “There are certainly some engineering challenges, but we have some incredibly gifted
“Because there is so much emotion surrounding the future of the Red Hill facility, the role of UH as an independent arbiter will hopefully go a long way in ultimately validating the results to bring greater objectivity among all parties involved.”

—BRENNON MORIOKA, College of Engineering Dean, UH Mānoa

scientists and engineers working on this from the Navy, industry and now—researchers from the University of Hawai’i (UH), to help ensure that the facility remains absolutely safe today and well into the future.”

Engaging UH Research — Letting the Science and Facts Speak for Themselves

Already familiar with the University of Hawai’i’s expertise in science and engineering through a number of collaborative projects over the years, the Navy turned to UH to independently assess the current condition of the tanks and to help develop technologies to improve on what it refers to as TIRM (testing, inspection, repair and maintain). Led by UH Vice President of Research and Innovation Vassilis L. Syrmos, a team of UH researchers and officials traveled to the Naval Facilities Engineering and Expeditionary Warfare Center at Port Hueneme, California last December to present a comprehensive proposal that involves the College of Engineering and School of Ocean and Earth Sciences and Technology at University of Hawai’i at Mānoa (UH Mānoa), Applied Research Laboratory at UH (ARL at UH) and funding by the Office of Naval Research. The proposal has been funded and work will commence this summer.

“In the current situation, a more careful long-term, scientific-based strategy is needed to achieve a balance between preserving both national security and O‘ahu’s water infrastructure,” said Syrmos. “By forming a strategic partnership with UH, the Navy has expressed their willingness and confidence in our researchers to deliver unbiased assessments, while providing the necessary expertise to explore current and future technologies in the areas of corrosion prevention, surface coatings, groundwater monitoring and double-wall containment.”

To begin the multi-phase project, corrosion research experts from the UH Mānoa College of Engineering will assess the current situation of the tanks using data collected by the Navy and by performing additional independent analysis. In addition to researching methods to measure the minimum thickness of the existing steel more accurately, they must also devise a protocol for measuring the in situ corrosion rate of the tank wall to help determine safe time intervals for repair and maintenance.

In subsequent stages of the project, the researchers plan to machine-in known defects (mimicking corrosion) into steel lab sample plates to analyze and verify the limits of detection of non-destructive testing (NDT) methods, then backfill the defects with specific types of corrosion products to determine if the same defects could be identified or if the signals were affected by the corrosion products—to improve the interpretation of NDT data to identify corrosion defects and estimate remaining plate thickness more accurately. They also plan to investigate tank-wall repair protocols, and investigate the feasibility of heat-resistant coatings that can withstand welding on a repair plate to enhance resistance to corrosion and crevice corrosion.

“Storage tanks are similar to airplanes, in that both are both are subjected to internal pressure and external elements,” said UH Mānoa College of Engineering Dean Brennon Morioka. “However, unlike aircraft, access to the entire structure of the Red Hill tanks is not possible, making the reliance on accurate scans of steel—taking into account any effects to the readings by any corrosion products—of extreme importance.”

Other researchers from the UH Mānoa College of Engineering will also be conducting research on NDT using drones and magnetic robot crawlers for both empty and fuel-submerged tanks; inspection of concrete degradation; and novel leak detection by analyzing products of microbial degradation; while the School of Ocean and Earth Sciences and Technology will further examine geologic conditions and conduct soil vapor monitoring; while ARL at UH will be concentrating their efforts on real-time sensor development and display, data analysis and information assurance work.

“We will be developing various sensor packages to increase the Navy’s ability to sense the environment in and around the tanks,” said ARL at UH Director Margo Edwards. “Our team will also be looking at ways to incorporate machine learning to securely distill data into a user-friendly dashboard for the decision-makers, while at the same time—working to deliver a communications system to help create more transparency for the general public about the facility.”

“As scientists, we want the science and facts to speak for themselves,” said Morioka, who also travelled to Point Hueneme to present his college’s capabilities. “Because there is so much emotion surrounding the future of the Red Hill facility, the role of UH as an independent arbiter will hopefully go a long way in ultimately validating the results to bring greater objectivity among all parties involved.”

Morioka added, “Many of our faculty involved in this partnership are long-time residents of the potentially affected communities and also share a vested interest in preserving the safety of the aquifer.”


RIGHT, TOP: Aerial view of Joint Base Pearl Harbor-Hickam.

RIGHT, BOTTOM: Fuel supply specialists service a ship at Joint Base Pearl-Harbor Hickam.

CREDIT: U.S. NAVY
UH West O‘ahu
Creative Media Facility
to Shine Brightly

“The new Academy for Creative Media Student Production Facility at UH West O‘ahu will serve as the hub for creative media education for the University of Hawai‘i and the state. It is a game changing, 33,000 square foot complex offering state of the art environments and technology, including streaming and transmedia production, VR/AR/MR, digital post production, eSports, animation, data visualization, screening room with Dolby Atmos mixing panel, and even an incubator space for student run companies. The $37,000,000 facility will instantly position UH, ACM System and UH West O‘ahu as one of the preeminent creative media programs in the world and the first with a majority Asian Pacific American student enrollment.”

–CHRISTOPHER LEE, Director, Academy for Creative Media, UH System
University of Hawai‘i

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