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The Planet, 2015, Fall

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DEAR READER,

As humans, we can't camouflage our skin like chameleons or run 120 kilometers per hour like cheetahs. We see, smell and hear more poorly than many of the earth's inhabitants. Our bare skin provides no barrier for sub-zero temperatures. Without adequate oxygen or water, bacteria will outlive us by billions of years. Yet despite biological setbacks, humans have powerful minds and dexterous hands, capable of creating great things. However those powers can also be destructive.

Since the beginning of our days building plows and irrigation systems to enhance agriculture to technological advancements like the combustion engine, nuclear bomb and even space exploration in the 20th and 21st centuries, the crescendo of human existence has undeniably impacted the planet.

Technologies are constantly introduced, enhanced and replaced with something new. Household and personal items are quickly outdated. But innovations to address environmental issues progress much more slowly.

In December, the United Nations will convene the 21st session of the Conference Convention on Climate Change in Paris. Over 500 representatives will discuss preventing global warming from increasing to more than 2 degrees Celsius above pre-industrial levels. Innovators will be pressured for clever solutions.

In this issue, we explore the exciting and ugly sides of innovation. We dig up controversial views from the "Ecomodernist Manifesto," follow a professor using drones for conservation research and we look at how batteries and pumped hydro are developing for renewable energy storage.

We follow the failed attempts to prevent sea lion predation on endangered salmon, witness the faulty implantation of a 3-D printed beak for a disfigured bald eagle and watch poachers escape jurisdiction, even after DNA points directly toward where they are seizing ivory.

Along the way, we learn how giant clams provide inspiration for future solar panels and meet a homebuilder who's eliminating utility bills with net zero homes.

Innovation drives and defines our species, but development has its limits and agendas are not always aligned. Be inspired by the innovations you read about in this issue, but remember — there's a lot of work left to do.

Keep digging.

Yvonne Worden
Editor-in-Chief

THE PLANET MAGAZINE is the quarterly student publication of Western Washington University's Huxley College of the Environment. We are dedicated to environmental advocacy through responsible journalism.

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THE TRUTH IS UP THERE
by Simon Bakke
Drones used for conservation research are highly regulated by the Federal Aviation Administration. More regulations and less costly devices may enhance their research capabilities.

ELIMINATING UTILITIES
by Alyssa Sanchez
Building residences with zero utility bills at hard-to-beat prices has the potential to change how homes are powered.

DEATHS IN THE RIVER
by Kate Welch
Sea lions are eating endangered fish in the Columbia River, but the sea lions’ protected status makes it difficult to stop the predation.

BEAUTY AND THE BEAK
by Vanessa Thomas
Scientists, engineers and caretakers explore the use of 3-D printed prosthetics for wildlife rehabilitation.

THE ECOMODERNIST DILEMMA
by Rose Richardson
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MOLLUSK MIMICRY
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by Sarah Climaco
Maureen Wall operates an aquaponics system where salad greens and fish live in a mutually beneficial ecosystem.

TRACKING THE TRADE
by Nanette Jackson
A University of Washington researcher has developed a new method to track elephant poaching but it’s not solving the problem.

ENERGY EVOLUTION
by Andrew Wise
As the need for energy storage grows, geography has the potential to challenge high-tech, chemically powered batteries.

ON THE COVER
As streets of downtown Vancouver, B.C. come alive at dusk, I watched people in their daily migration from the natural world to their urban environments. Although the contrast was like day and night, I could see a vibrant, dynamic ecosystem in both, steadily adapting and changing through evolution, innovation and ingenuity.

-Jesse Nichols
Photo Illustration by Jesse Nichols and Kjell Redal
THE TRUTH IS UP

STORY BY SIMON BAKKE
PHOTOS BY MELISSA BENEDICT
Dr. David Wallin pulls a gray plastic orb from a padded hard case and clicks it into the center of a four-legged base. From the outside, it looks like an Apollo lunar lander made of Super Nintendo plastic. He screws on the four black propellers and sets it gently on the laboratory table.

This tiny quadcopter, however, holds hardware, scientific sensors and cameras worth more than a Tesla Model S. It's registered with the Federal Aviation Administration the same way as a Boeing 747.

Researchers and conservationists use aerial drones for everything from monitoring unpredictable rivers to tracking endangered orcas in the Puget Sound. The laws, costs and technology are changing at a whirlwind pace. The world of drones, or unmanned aircraft systems, looks radically different than it did five years ago. While the equipment is heavily regulated and sometimes expensive or difficult to acquire, the coming years could transform how these little aircrafts help to study, map, film and think about the planet from above.

Wallin, a professor of environmental sciences at Western Washington University Huxley College of the Environment, first became interested in using UASs to enhance his research tracking elk populations in the Skagit Valley in Washington state. He flew a Raven, a military surplus drone, to try out a novel way of studying ecosystems.

Moving from concept to implementation, however, took a full year and a half of getting permits and passing tests before he could get his first flight up in the air.

Wallin, like any scientist who works for a public entity, had to pass the same written exam a private pilot does in order to be allowed to fly a UAS for research.

"[It] is ridiculous, because 99 percent of the material is irrelevant to flying unmanned aircrafts," Wallin said.

He also had to get an FAA Class 2 Medical exam, the same medical clearance required of commercial pilots. Researchers must register any drone using its "N-number," the same way a commercial aircraft is registered, whether it's the size of a jumbo jet or smaller than a remote-controlled airplane, according to an FAA 2014 factsheet.

For recreational pilots, it's a different story. They can purchase and fly an identical, personal unmanned aircraft under 25 kilograms without any permits or exams as long as they stay below 122 meters and out of an 8 kilometer radius of airports.

Left: Max Romey, a Fairhaven College senior and drone videographer, holds his DJI Phantom quadcopter drone while the propellers rotate. According to DJI, this entry-level drone can operate 5.17 kilometers away from its controller. Romey has used it to film in Alaska.
"Watching what [Wallin] had to do for the legality of it, because he's working with a university, was insane," said Max Romey, a Fairhaven College of Interdisciplinary Studies senior who accompanied Wallin on a Raven flight in the Skagit Valley.

While Wallin is intrigued by the possibilities of drones, other researchers have stuck to proven methods. Teams from the United States Geologic Survey and the Bureau of Reclamation had unsuccessful results when trying to use drones to monitor two reservoirs on the Elwha River on Washington's Olympic Peninsula, said Andrew Ritchie, the Elwha Restoration Project hydrologist. For the roughly 80 flights Ritchie has done in the area, he instead used a piloted Cessna with a wing-mounted camera.

"Drones are sexy but still an infant technology, over-regulated and suitable primarily for small-scale projects," Ritchie said in an email.

Even after a year and a half of work leading up to the study, Wallin ran into a similar problem. The Raven ended up not producing useful data on the elk because of difficult terrain in their survey location and the aircraft's primitive autopilot technology.

But the industry is changing, Romey said. His trip with Wallin on the elk survey helped him realize by how much. Romey, an owner of a drone himself, flew drones as a filmmaker for three years and said he has seen the industry explode in that time.

"Here I was 10 years [after the Raven's creation, and] my Phantom, a $500 drone, could basically do the same thing," Romey said.

During and after these surveys, Western Washington University adapted. The university acquired three new drones through a Student Technology Fee grant, the quadcopter in 2013 and two fixed-wing models in 2014—all more sophisticated than what Wallin used in the Skagit Valley. The quadcopter alone cost over $100,000 and the two fixed-wings together around $25,000.

Even since then, the technology has come a long way, Wallin said. Today, a quadcopter for under $2,000 is functionally quite close to the prior model—about 60 to 80 percent as capable by Wallin's estimates. He hopes to raise more money to acquire a few of these relatively inexpensive vehicles that students can check out for research purposes.

"It is too good of a technology not to start sharing. Really, the students now who are going to be using this technology will be the ones who really develop and change the industry, both for the drones themselves and how they're used," Romey said.

In February 2015, the FAA proposed changes that would only require public drone operators like Wallin to pass a UAS-specific knowledge test, eliminating a significant barrier. The manual Wallin once used to study for his complete pilot's exam still sits on his office bookshelf, about as thick as a Harry Potter novel.

"I'm convinced that within five years, [UASs] are going to be as ubiquitous as GPS and tape measures for scientists," Wallin said.

Administrative hoops and hang-ups notwithstanding, other scientists are finding ways UAS technology can get their work off the ground. Biologists with the National Oceanic and Atmospheric Administration fly drones to keep tabs on Puget Sound orcas, getting close enough to observe their well-being but far enough away to not disturb the animals. Conservationists in Indonesia have also used drones for real-time mapping and monitoring illegal land usage. They are more cost-effective and accessible than using satellites or plane-mounted sensors.
Likewise, Wallin envisions using the university quadcopter to do unobtrusive salmon spawner surveys, hovering just meters above streams. Whatcom County officials also recently asked Wallin to use the aircraft for monitoring a stream near Glacier, Washington that is putting the town at risk of flooding and landslides. He said he has not given up on the Skagit Valley elk either, and plans to fly over flatter, more manageable terrain to see how easily elk can be monitored.

"Since we started experimenting in flight, with the Wright brothers and kites and the first planes, they were searching for the same stuff we are with these new drones now," Romey said, "They’re just looking for a new perspective." 

**SIMON BAKKE** is a senior studying environmental science. He wants to bridge the gap between science, graphic design and writing to help people think outside the box.

**MELISSA BENEDICT** is majoring in recreation, with a focus in outdoor recreation, and double minoring in environmental studies and anthropology. She loves studying how nature makes people tick and bringing her observations to life through her photography.

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**ABOVE LEFT:** The underside of Romey’s quadcopter houses a black rectangular fixture called the gimble. This is where a GoPro camera would be attached. It moves freely and fluidly during flight in order to stabilize the camera and facilitate high-quality video recording. The small grey balls are used to absorb shock and small vibrations while the white legs on either side keep the gimble off the ground.

**ABOVE RIGHT:** An elk herd that Wallin has studied grazes in a field in the Skagit Valley during a rainstorm. The Sauk-Suiattle tribe planted this field specifically for wild elk as part of their conservation efforts. The portion that is plowed will soon be planted with clover.

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The herd of elk that Wallin tracked with drones run through the rain in a field in the Skagit Valley. The elk on the right wears a tracking collar around its neck that aids Wallin in other aspects of his research.
ABOVE: Ted W. Clifton explains the system that pumps hot water through the concrete floors of his net zero house. This system is what heats the house.

Ted W. Clifton, dressed in a paint-stained T-shirt and sporting a long beard, enters the Power House, a home that is the first of its kind in Whatcom County. The home is brightly lit by the last of the afternoon rays beaming through the large, south-facing windows. The azure-blue cement floors trap the solar heat, keeping the house at a comfortable 21 degrees Celsius. At first glance, this house might appear like any other on the street, but this home may make utility bills a thing of the past.
CLIFTON IS THE founder of TC Legend Homes, a Bellingham, Washington-based company specializing in building net zero homes, such as the Power House. The uncertainty surrounding the affordability of green buildings, whether they are residential or commercial, has prevented buyers from investing interest, time and money into considering net zero homes as an option. Clifton’s goal is to alleviate this stigma and prove homeowners can live in a house that is energy efficient at an affordable rate.

According to the Department of Energy, net zero buildings meet their annual energy consumption requirements by producing most, if not all, of their energy on-site, thereby reducing the building’s need for nonrenewable forms of energy, such as fossil fuels. Net zero homes aim to have lower environmental impacts and operating costs, and are more resource efficient compared to a traditionally built home. By creating all of its own power, the Power House, along with six other net zero homes Clifton has built, have eliminated monthly electricity and heating costs.

“We’ve been able to show that we can do net zero for less than what most people are building regular houses for. We just make different choices,” Clifton said.

In order to deliver a home that creates all of its own power, Clifton implements a 12-step design that cuts expenses that can be installed later, like granite countertops or hardwood floors, and instead invests that money toward energy efficient appliances and technologies.

INSIDE THE POWER HOUSE

One of the least expensive features Clifton implements into the blueprint of his homes is passive solar design, a concept that allows a home to take advantage of solar energy. Passive solar design positions the long side of the home to face south, with the roof ridge orientation built from east to west. The roof overhang angle is designed to keep the house from getting too hot in the summers when the sun is high, while still keeping it cool inside. In the winters, warm air can be trapped while keeping the colder air out.

“I'll drive by houses that are being built and they won’t have any windows facing south, or they didn’t point the house the right way,” Clifton said. “It’s just so easy.”

South-facing windows absorb solar heat, an imperative feature in eliminating heating costs. Heating and cooling account for the largest amount of energy consumption, about 48 percent of energy use in a typical home, according to the DOE.

Clifton said he uses a particular brand of windows that are as well insulated as nearly 4 centimeters of Styrofoam. The high-performing windows work in sync with the rest of the house, absorbing and then storing heat in the floors and walls to keep the house warm. Choosing a window of this particular design also allows for more visible light into the house, cutting costs on light fixtures and energy.

Within the skeleton of the home are structural insulated panels, 20-centimeter thick Styrofoam sandwiched between two sheets of plywood. The SIPs are installed in the walls and floors to create a tight seal so they absorb and hold excess solar energy, preventing any heat loss that would occur in a typical home, Clifton said.

KEEPING NET ZERO AFFORDABLE

The most costly aspect of the home is the 36 solar panels. The initial investment of $40,000 may seem daunting but the panels generate all the electricity to power the home and cars. Clifton said he hasn’t gone to a gas station in six months. He and his partner pay about $28 collectively to charge their cars every month. More savings are generated in the long run when utility bills and fuel costs are eliminated.

On sunnier days when the Power House is generating more electricity than it uses, the excess is sent to the power grid. Clifton pays a monthly fee of $8.35 to be connected. When the house is not generating enough electricity, it can pull energy from the grid if needed, Clifton said.

The Power House lot was purchased for $106,000 and building costs ended up at $430,000, including the hours of labor that Clifton put in, he said in an email.

TOP: Clifton stands outside his house with his son, Atlas. The house was completed in spring of 2015 and Clifton and his family have been living in it for the past six months.

BOTTOM: Clifton and his partner charge their cars, a Tesla Model S and Nissan Leaf, from the 36 solar panels installed on their roof. He says that he hasn’t been to a gas station in six months.
Eric Thomas is the first homeowner of one of Clifton’s net zero homes in Ballard, Washington. Clifton built a three-bed, two-bathroom home for Thomas priced at $390,000. In 2013 when the house was built, a residence of those dimensions in the Ballard neighborhood could range from about $450,000 to $600,000, according to data from Windermere Real Estate.

Clifton cuts costs by investing money toward technologies that make homes more efficient and comfortable.

"[There was] a real comfort difference when we moved in," Thomas said. "The new house has radiant floors where it stores thermal energy, and the whole house is heated through them so it feels warm on your feet. It’s a totally different feeling."

LOOKING FORWARD

There are still barriers keeping net zero housing from being perceived as commercially viable. There needs to be increased education among consumers and the real estate industry about the positive implications for an energy efficient home, said Steve Abercrombie, vice president of the Northwest EcoBuilding Guild.

"Net zero homes can be built at or below market price," Abercrombie said. "There is no question of their commercial viability."

Sam Rashkin, chief architect for the DOE Building Technologies Office, said misconceptions around net zero housing are that they cost more than other homes on the market and face significant challenges before the technology is ready for the market.

Though the initial sticker price may be higher, in the long run, investments are returned with reduced utility costs, and the technology is already available, Rashkin said.

"They offset substantial amounts of fossil fuel consumption for electricity, heating and hot water. The big environmental benefit is reducing the carbon footprint," Rashkin said.

Abercrombie said he is already seeing an increased demand for net zero, passive and other higher performing energy homes.

As the Power House takes in the last of the sun’s warmth, Clifton gathers his daughter from the greenhouse and son from the garden to get ready for dinner.

Clifton and his team at TC Legend Homes are providing net zero homes that are affordable and available now.

"This little family has proven that you don’t need fossil fuels," Clifton said. "We don’t need coal, we don’t need oil, gasoline, we don’t need any of it."

ALYSSA SANCHEZ is a junior studying public relations with a concentration in geography. She hopes to pursue a career as an environmental public relations specialist. She enjoys exploring new places, writing and a cup of hot tea.

KESIA LEE is a passionate visual journalist who believes in the power of a photograph to inspire people and create global change.

PASSIVE HEATING AND COOLING

A passive home design, as defined by the Passivhaus Institut, must consume no more than 120 kilowatt-hours of energy per square meter of living space—about 11 times less than the energy consumption rate of the average American home.

The average conventional home consumes energy at a rate of 1,335 kwh/m^2 per year. A passive home only consumes 120 kwh/m^2 per year.

GAS VS. SOLAR

Source: U.S. Energy Information Administration
Hundreds of sea lions bark thunderously, gaping wide-mouthed as they are approached. The barks echo in the basin near the mouth of the Columbia River in Astoria, Oregon. The sea lions begin to bark louder, frantically scurrying off the docks where they had been lounging. One hits a spigot on the dock and water sprays across the path, painting the scene with mounting chaos.
PROTECTED UNDER THE 1972 Marine Mammal Protection Act, two species of sea lions are eating endangered populations of salmon and protected status, so they are forced to creatively handle the situation.

The number of native Steller sea lions and visiting California sea lions, both part of the pinniped family, has increased in recent years, from 30 sea lions observed at the Bonneville Dam in 2002 to over 130 in 2014. The sea lions weren’t a danger to the fish or the docks until recently.

“We started to see a turnaround in the 1980s with a gradual increase in the numbers of the pinnipeds returning to the Columbia River,” said Robert Evert, the permit and projects manager at the Port of Astoria.

Key areas along the Columbia River, such as the Port of Astoria’s recreational fishing marina, have become crowded by sea lions jumping up on the docks in order to rest on their way to the Bonneville Dam fish buffet.

The pinnipeds damage the docks because of their sheer size and their tendency to get into fights. With sea lions crowding the surface, the docks in the marina become difficult to use.

In June 2015, the Port of Astoria deployed a fiberglass orca armed with orca feasting sounds with the intention of trying to scare the animals off the docks. The fake orca quickly capsized and had to be sent back to Island Mariner Cruises in Bellingham, Washington, for repairs. The event, however unsuccessful, was highly publicized.

The Port’s problems are just a symptom of a larger issue that’s not going to be solved with fake orcas, said Traci Belting, the mammal and bird curator for the Seattle Aquarium.

The Astoria marina is only a pit stop on the way to eat endangered fish in large amounts in the area immediately downriver of the Bonneville Dam.

When the Bonneville Dam opened in 1938, the migratory patterns of fish traveling up the Columbia River to spawn would never be the same. The dam’s fish ladders, said Washington Department of Fish and Wildlife Spokesman Craig Bartlett, are a significant obstacle in the way of spawning grounds for Chinook salmon and Steelhead trout, two endangered fish species the sea lions prey on in the lower Columbia River.

“The problem here is the fish, when they’re moving upstream and they encounter an obstacle, they stay put for a while before they go up the fish ladders,” Bartlett said. “It’s just a big pool under there for [400 meters], and it really is sort of eating fish in a barrel.”

As the population of sea lions travelling upriver to follow the salmon increased, so did their consumption of endangered salmon and trout. Another problem is the sea lions make no differentiation between the heavily protected wild fish and their hatchery-bred counterparts that are less protected, Evert said.

“The sea lions don’t care,” Evert said, “Not only are they killing the hatchery fish which were re-introduced to recover the stock and to provide fish for recreational and commercial fishing, they’re killing both off indiscriminately.”

To counteract the surge in sea lion-related fish deaths, a joint force of the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife and the Columbia River Inter-Tribal Fish Commission began full-time hazing efforts in 2006.

Hazing teams are allowed to use a variety of methods, according to a 2014 publication from National Oceanic and Atmospheric Administration Fisheries. The teams have set off underwater firecrackers, shot rubber bullets and fired air horns in hopes each California sea lion present would stop eating up to 198 endangered fish each spawning season, according to a report by the Army Corps of Engineers.

“THE SEA LIONS DON’T CARE. NOT ONLY ARE THEY KILLING THE HATCHERY FISH WHICH WERE RE-INTRODUCED TO RECOVER THE STOCK AND TO PROVIDE FISH FOR RECREATIONAL AND COMMERCIAL FISHING, THEY’RE KILLING BOTH OFF INDISCRIMINATELY.”

ROBERT EVERT
PERMITS & PROJECTS MANAGER, PORT OF ASTORIA

PATH OF THE PREDATOR: MIGRATION DISTANCES TO BONNEVILLE DAM

From Astoria, Oregon near the mouth of the river, the sea lions swim over 200 kilometers upriver to eat fish at Bonneville Dam. The California sea lions, which are often found as far south as Baja, California or Mexico, might swim in from as far as the California Bay Area near San Francisco, a swim of almost 1,500 km to the Bonneville Dam, which would take 21 hours for a human to drive.
Belting said she didn’t think the fiberglass orca, or any other hazing method, would be effective in the long run.

“If you work with sea lions, they’re really, really smart,” Belting said, “It’s kind of like putting a cat in front of a dog versus a statue of a cat, which one do you think the dog is going to chase?”

Belting, a former marine mammal trainer, was part of a panel of specialists to recommend actions to take based on their knowledge of sea lion behavior. Hazing alone isn’t enough to stop the sea lions killing or eating the fish, she said.

“Aversives and deterrents such as seal bombs were being used to try and deter sea lions from going there,” Belting said. “Unfortunately, over time it’s kind of like a kid living in the city, you just don’t hear the sirens at night anymore, you don’t hear the train anymore.”

The Army Corps of Engineers, which manages Bonneville Dam, also uses physical barriers to prevent the sea lions from entering the fish ladders, making the entrances too small for them to enter and continue travelling further upriver, said spokeswoman Diana Fredlund.

The Corps of Engineers also employs workers who watch the sea lions so that the states and tribes can know how much of the endangered fish populations are being killed. In 2007, the pinnipeds at Bonneville Dam were seen eating or killing 5.1 percent of the salmon run.

In 2008, NOAA Fisheries granted permission for the joint state and tribal departments to take lethal measures against the California sea lions.

According to Bartlett, killing the sea lions with lethal injections or removing them from the area has been the most effective method stopping them. In 2014, 32 sea lions were killed and two others were taken to zoos. Since 2008, the amount of the run being eaten at the dam by California sea lions decreased to 2 percent, or just over 5,000 fish.

In 2008, when NOAA granted authorization to use lethal force on California sea lions, only 39 Steller sea lions were sighted at Bonneville Dam.

Then the situation changed, and Steller sea lions became the primary predators immediately below the dam. In 2014, that number almost doubled to 65.

In 2015, U.S. Rep. Jaime Herrera Beutler introduced HR 564, a bill that would allow for lethal force against all sea lions, including Steller sea lions, for the next five years. The departments of Fish and Wildlife in Washington and Oregon have stated their support of the bill, indicating over 45 percent of the spring Chinook salmon run may never reach Bonneville Dam.

Congress has not voted on HR 564 yet.

The states and tribes have to try to balance the the importance of the fish versus the importance of the pinnipeds.

“The problem is, [the Steller sea lions] were an endangered species, so you have an endangered species that’s preying on an endangered species,” Belting said, “Which one wins?”

Other methods, such as river-wide barriers and sea pens, have been proposed and would leave the pinnipeds unharmed, but aren’t realistic due to prohibitive costs, Belting said.

“No one’s willing to say, ‘well, let’s not have any bus service in Oregon. Let’s use that money to help save sea lions.’ There’s only so much money in the government coffers.”

KATE WELCH is a junior at Western Washington University who enjoys photography, urban planning and making maps.
In 2005, a 6-year-old bald eagle named Beauty was shot by a poacher resulting in the loss of over 80 percent of her upper beak. The injury also left both her tongue and sinuses exposed and made it impossible for her to independently feed herself. Janie Veltkamp, executive director of Birds of Prey Northwest, based in St Maries, Idaho, recovered Beauty from a rehabilitation center in Anchorage, Alaska in 2008.

As both a nurse and a biologist, Veltkamp was interested in securing a prosthetic beak, allowing Beauty to carry on with daily life. Three-dimensional printing is still in its beginning stages and its applications within the medical world are still being discovered. Recent experimental uses include a tracheal splint in a human newborn. 3-D printing is also being researched for making biodegradable scaffolds for tissue engineering. Printing a beak was well within the realm of possibilities.

"Here was this magnificent bald eagle missing only about five centimeters of her biology, yet rendering her totally dependent on humans because she cannot feed herself without her upper beak," Veltkamp said.

This is where Nate Calvin, mechanical engineer and founder of Kinetic Engineering, a 3-D printing company based in Boise, Idaho, came in. Calvin learned of Beauty's situation when Veltkamp gave a presentation on birds of prey in Boise.

Printing a beak had never been done before. However with 3-D printing, it's only the application changing, not the process.

"I needed side profile shots, top view, front view and I needed a couple of them to have a scale ruler in the background so I could actually take dimensions of Beauty," Calvin said. "To get the physical form, the 3-D complex form, and the rest of the facial features, I told her I had to have an impression. The same kind of impression you get when you go to the dentist."

Calvin calculated the photos and impression into a design program. Although there are many different types of 3-D printing, Beauty's beak was printed using a technique called stereolithography, or SLA.

The process involves a vat of liquid photopolymer resin being hardened and shaped by an ultraviolet laser, layer by layer to print a solid 3-D model.

In order to attach the SLA-printed prosthetic to Beauty's remaining beak, she had to undergo a 2-hour procedure. The prosthetic was attached to Beauty's beak in a similar manner to a person getting a crown installed on one of their teeth.

Once the prosthetic was attached to the remaining part of Beauty's beak, she immediately began to behave naturally by drinking water and preening her feathers, Veltkamp said.
The Kinetic Engineering group created a 3-D mockup for Beauty’s beak to be used in a program that would render it for a 3-D printing. Photo Courtesy of Kinetic Engineering.

A 3-D printer in the Student Technology Center at Western Washington University prints a small blue dinosaur. Printers like these created Beauty’s prosthetic beak.

Beauty the bald eagle sits at the Birds of Prey Northwest in St. Marie’s, Idaho, where Janie Veltkamp cares for her. Beauty is one of the first animals to receive a 3-D printed prosthetic after a poacher shot off almost all of the top part of her beak.

While Beauty’s new prosthetic may have seemed like a great solution, it was only a temporary one. Although Beauty had only about 10 percent of her upper beak remaining, as time went on it continued to grow a couple of millimeters and eventually pushed the prosthetic piece completely off.

“I told people all along it was experimental in nature and we had no idea what the final outcome would be over the long term,” Veltkamp said.

Even though Beauty no longer has the prosthetic beak, she has been able to independently feed herself with a special feeding board and a reshaped lower beak.

It would be nice for 3-D printing to be the answer for animals in need of prosthetics, said Nickol Finch, an assistant professor of zoological animal medicine at Washington State University. But it is too early to tell one way or the other, she said.

Despite media hype and the many potential applications of 3-D printing, it is not always a realistic solution for all medical problems. Printed prosthetics for animals pose unique challenges.

“It’s not like an amputee who still has a way to function even with a prosthetic,” Finch said. “Their development and anatomy is the way it is for a reason and we can’t necessarily just change that and add something that isn’t going to grow and adapt with the animal.”

As for Beauty’s beak growth, it is hard to know for certain whether it will continue to grow at all, let alone return to its original state in her lifetime. Finch describes bird beaks as being similar to the human fingernail.

“The nail will continue to grow as long as you still have the germinal layer, the white line around the fingernail—this is the reason Beauty’s prosthetic beak was pushed off,” Finch said. “If the damage is back into the germinal layer, then parts of the beak may grow, but other parts may not.”

Finch said problems with prosthetics arise because there may not be a normal beak left afterwards. In theory, as long as the shape of the beak was okay than Beauty should be able to use her beak just as she had before.

Now, 15-year-old Beauty weighs about 5.5 kilograms, has a 2-meter wide wingspan and can grow even larger in the future. However, Veltkamp does not see Beauty being released back into the wild due to the condition of her beak. Two other birds, toucans Tieta and Grecia, have received 3-D printed prosthetic beaks within the last year.

Although Beauty may never fly freely again, her situation is informative for scientists, engineers and caretakers for what is possible in the field of wildlife rehabilitation.

VANESSA THOMAS is a senior studying news editorial journalism with a double minor in political science and communication studies. Along with writing and photography, she loves to play the cello and go for long runs through forests.

ANNA KERR is an fine arts major with a photography concentration. She hopes to pursue a photojournalism career and cover social and environmental issues throughout the world.
Invasive species, such as zebra mussels and Himalayan blackberries, are dwarfed by the widespread impacts humans have on the earth. Humans have altered environments so much that scientists have proposed a new geological era called the Anthropocene. In an effort to embrace the Anthropocene and grow in a less destructive way in the future, two men have drawn up a plan of action: step away from nature.
Since founding the Breakthrough Institute in 2003, eco-pioneers Ted Nordhaus and Michael Shellenberger have presented contentious ideas about how to preserve the planet’s wild places. In April 2015, along with 16 other authors, they published the Ecomodernist Manifesto. Their ideas to intensify urbanization, further develop nuclear power and “decouple” from nature might sound different from conventional environmental theories, but their end goal remains the same: save the planet.

“We think we have the capability and responsibility to lower our impact as much as possible while continuing to deliver the capability of living a modern life to the billions of people who still live in poverty today,” said Alex Trembath, senior energy analyst at the Breakthrough Institute.

Remedying the loss of natural places is one of the core values of the ecomodernists, Trembath said.

If the goal is the same, then what makes the ecomodernist theories so different?

“I think at the end of the day people care more about their environmentalist identities than they care about the environment.”

Alex Trembath, Senior Energy Analyst at the Breakthrough Institute
“Just thinking we’ll do it
because it’s the smart thing
to do isn’t enough.”

DAVID ROPEIK, RISK PERCEPTION
PROFESSOR AT HARVARD UNIVERSITY

“You might have to challenge a
bunch of basic identities, and a bunch of
your assumptions of what’s good for the
environment,” Nordhaus said. “I think at the
end of the day people care more about their
environmentalist identities than they care
about the environment.”

Shellenberger and Nordhaus said that
climate change will need to be addressed in
the context of alleviating poverty in poorer
countries, allowing them to develop like
wealthier countries have done so already.

Washington state’s main source of energy
is hydropower, which generates almost two
and a half times more energy in the state than
natural gas and coal combined, according to
a 2006 report by the Department of Ecology.
Hydropower is carbon-free, renewable and
globally available.

Yet in many developing countries, hydropower is not being used like it could be. Less than 40 percent of people in sub-Saharan Africa have access to electricity—many use wood and dung as fuel instead, according to a 2010 study.

Africa’s hydropower industry produced
76,000 gigawatt hours of electricity in a
two year period, only 4 percent of what the
continent could be producing, according to a
2002 study in the journal Energy Policy.

Many sub-Saharan African countries are
dependent on foreign private investment for
hydropower operations, stalling construction
and operation. On their own, these countries
don’t have enough money to build and maintain
hydropower plants, providing energy for those
without access to electricity.

Using hydropower instead of wood for
fuel could reduce deforestation in these areas.

By supporting the modernization of the
developing world the ecomodernists believe
humans can move toward a far less ecologically
destructive future, Nordhaus said.

David Ropeik, a risk perception professor
Harvard University and an environmental
writer, said there is potential in some of the
ecomodernist ideas, but believes the main
obstacle is entirely different.

“The challenge to the idea of the
ecomodernist approach is it requires, and this
is their word, wisdom,” he said.

In his response article to the manifesto,
Ropeik said the wisdom required to put the
ideas in motion is humanly impossible on an
individual level. On the other hand, leaders
have the resources to put the ecomodernists’
ideas in motion, but they are swayed by the
needs of consumers and markets.

THE ANTHROcene
BEGINNINGS
Infographic data is based on
David Christian’s “Maps of Time.”

COLUMBUS SAILS
TO AMERICA
Reforestation after invasion
causes a “little ice age”
(Orbis Spike)

STEAM ENGINE
Coal-powered engines cause a
spike in atmospheric CO2.

PRODUCTION OF NITROGEN
Nitrogen levels in soils spike
after industrial processes begin
fixing atmospheric Nitrogen.

FIRST NUCLEAR WEAPON
First Nuclear Weapon:
Explosion releases first human-produced radioactive isotopes.
"Just thinking we’ll do it because it’s the smart thing to do isn’t enough," Ropeik said. But the ecomodernists remain hopeful. According to the manifesto, there’s plenty of space for everyone, and humans have the technology to be entirely independent from nature and lower their impact.

The developed world can change their habits to support this as well, Shellenberger said. Nuclear power plants have been a proven source of carbon emissions-free energy. However nuclear power has also stirred worldwide fear after the atomic bombs in World War II and the meltdown of the Fukushima power plant in 2011.

John Dobken, a representative of Energy Northwest and Washington’s only nuclear plant, Columbia Generating Station, said the reputation of nuclear power is misunderstood and the debate over the safety has changed. There has only been one minor nuclear accident in the 50 years nuclear power has been in operation in the U.S., and no accidents at the Columbia Generating Station in its 30 years of operation, Dobken said.

"The safety record of the nuclear industry is the best, yet we’re being asked about safety," he said.

After incidents like the Fukushima meltdown, Dobken said the safety of nuclear power plants has been taken very seriously. Although the plant survived the massive 9.0 magnitude earthquake in Fukushima, it was still overtaken when the tsunami flooded the reactors.

Ropeik said the pros of nuclear far outweigh the cons. His exploration into the research of nuclear technology uncovered the risk of cancer in survivors of the atomic bombs of World War II—studied intensively for 70 years after immense exposure to radiation—increased by less than one percent.

By comparison radiation levels in nuclear power plants are much lower than fallout from nuclear weapons. While the reputation of nuclear energy is contentious, the efficiency of nuclear technology and the lower-than-expected health impacts still makes it worth exploration, Ropeik said.

However, Earth Day founder Denis Hayes is doubtful nuclear power is a form of energy technology everyone can use. Nuclear plants are very costly to construct, nearly four times as expensive today than in 1976. At this cost, nuclear energy can’t compete with other production methods, Hayes said.

"I favor technologies we can enthusiastically share with all people and nations—hopefully reducing the canyon between the obscenely wealthy and destitute," Hayes said in an email.

The end goals of the Ecomodernist Manifesto are to save wilderness and reduce human impact on the planet so it can recover. Fred Pearce, author and environmental writer for New Scientist Magazine, is unsure the world is ready to implement ecomodernist ideas. But feels nature is resilient and people, though they may not agree on how to get there, have the same goal in mind.

"Everything’s kind of screwed up, but the good news is nature carries on in many ways," Pearce said. "Nature’s quite versatile, nature’s quite resilient, nature finds a way through, and I think that’s a source for optimism."
Sun-soaked coral reefs in the Western Pacific provide a vibrant and hospitable ecosystem for plants and animals, but excessive sunlight is potentially harmful to organisms living there. Beneath the water’s surface lie brilliant, iridescent giant clams harnessing sunlight and acting as efficient miniature solar energy plants, channeling energy to grow their own food.

The clams share a symbiotic relationship with algae growing within their shell. They have developed cells to reflect light in a way that filters out harmful wavelengths while channeling useful light to redistribute it to the algae evenly. Further study of these cells could change the way solar energy is harnessed.

The application of clam cells and other natural mechanisms for human innovation is called biomimicry. It is being used to create more efficient wind energy by examining whale physiology, to address noise pollution from high-speed trains by modeling their design after the shape of kingfishers, to design groundwater filtration systems by imitating earthworms and to invent new surgical staples by studying porcupine quills.

The public can’t rely solely on mimicking nature, and in order to successfully produce useful tools, mechanisms found in nature must be used as inspiration and integrated with our current tools, said Jeff Karp, a biomedical technologist and professor of medicine at Harvard University Medical School.

“Biomimicry is where you copy nature in every detail, whereas bioinspiration is where you’re taking some sort of idea in nature, and then improving on it for your own purposes,” Karp said.

The largest giant clam of the tridacnidae species can grow over a meter long and weigh over 200 kilograms. Iridescent cells drape over the clam shell and cover the inside, or the mantle, of the clam, producing vibrant colors spanning the entire spectrum of visible light. The colors change when viewed from different angles, much like the feathers of a hummingbird.

The cells that give the clam its unique glowing colors are nanostructures called iridocytes, which produce iridescence by interacting with light and reflecting it. Several other organisms, such as cuttlefish, octopuses and squid, contain these cells as well, but they are used for mating, camouflage and communication, according to a 2013 article in Proceedings of the National Academy of Sciences.

Daniel Morse, a researcher leading the study, knew the clams weren’t using iridescence for any of these reasons. But he wasn’t sure of their purpose.
“It was thought, ‘What’s that doing for the clam? Well, maybe it’s acting as a kind of sunscreen,’” Morse said.

It turns out the cells are used to funnel sunlight to algae of the genus *symbiodinium*, growing photosynthetically inside the clam. The algae produce nutrients for the clam, which keep the clam healthy and allow it to grow. In return, the clam provides a safe-growing environment for the algae. The system allows for algae to efficiently use available sunlight while mitigating damage that excess and non-useful light may cause.

“Of course it has implications for solar energy, for manmade apparatuses,” Morse said. Morse and other researchers at University of California, Santa Barbara are studying iridocytes and trying to learn how to apply them to create new 3-D solar cells.

“What we’ve been studying further is how these iridocytes work, what the proteins are that give them this [reflective] property, and how we can translate that to a radical new design of solar cells that can take advantage of this property,” Morse said.

Current solar cells are limited by being two-dimensional. Energy from the sun is absorbed in the first layer of a solar panel. Making a 3-D panel using current technology won’t work. The clams, however, are able to uniformly illuminate all the algae in a densely packed area by using iridocyte cells to reflect light, acting as a 3-D solar converter.

“Probably the biggest consumer-perceived issue [with current solar cells] is the efficiency isn’t very high,” said Karl Unterschuetz, the director of business development at Itek Energy in Bellingham, Washington. However, efficiency isn’t an issue with current solar panels until more available surfaces are covered, said Unterschuetz. There is enough surface area on rooftops that can be covered to offset a large portion of power using current solar technology.

One of the largest efficiency issues manufacturers deal with is shading. If one of the cells in a panel is covered by shade, the flow of electricity across the panel is restricted, reducing the rate of energy production.

“If the 3-D cell could reduce the impact of light in shading by creating more diffused light, even in shaded situations, and be able to reduce that impact of going from a conductor to a restriction, then yes, I can see that being helpful,” Unterschuetz said.

Additionally, if 3-D solar cells can bounce light off the edge of the area of electrical generation, fewer materials would be needed for the solar panels, making the product cheaper, he said.

Morse and his team are beginning to develop new technologies using proteins found in iridocytes to adjust emissions from plasmonic nanoparticles, extremely small particles that efficiently scatter light, according to a January 2010 article in the *Journal of Quantitative Spectroscopy and Radiative Transfer*. The cells are inspiring new solar panels.

Morse said the question is whether a redesigned 3-D solar cell can save on area and reduce maintenance.

The clams could serve as a new model for creative solutions to energy production. The more understood about the clam system and its evolution, the more efficient solar energy, food and chemical production might be. The process of evolution has given humans potential solutions to their problems, through answers billions of years in development.

PASSING THROUGH A LAYER OF TINY CELLULAR LENSES AT THE MOUTH OF THE GIANT CLAM, SCATTERED LIGHT FUELS THE ALGAE CELLS GROWING WITHIN THE CLAM’S MANTLE TISSUE. THIS EFFECT ALLOWS MORE LIGHT TO BE ABSORBED WITH LESS SPACE, POTENTIALLY INFORMING THE DESIGN OF FUTURE SOLAR PANEL TECHNOLOGIES.
Inside a yellow historic building in Port Angeles, Washington, the flow of water is heard through the walls of a basement, where Maureen Wall feeds worms to a tank of fish. The water inside the tanks will eventually be pumped to rows of plant beds outside. Once a sculptor by trade, Wall now channels her creativity through the art of aquaponics—a symbiotic growing system producing edible plants and fish.

Maureen Wall owns one of the largest aquaponics operations in Washington state she named This is Odd: An Urban Aquaponics Farm, established it in 2010. Aquaponics operations like Wall’s combine soilless farming with aquatic fish farming. Wall built and maintains the 7,500-liter operation almost entirely on her own. While there are many challenges to managing her facility, Wall continues experimenting with aquaponics.

Aquaponics systems are dependent on fish because their feces provide nutrients for the plants. The fish tanks are kept in the basement where the water temperature is stable enough for the fish, eliminating the need for water heating systems.

Wall uses less energy running her system this way, however, it doesn’t always yield the best results. In July 2015, the Arctic char
in her fish tanks died when water temperatures rose to 21 degrees Celsius, too warm for their survival. While she searches for a suitable fish that can withstand temperature fluctuation, she's been using goldfish and koi.

Every hour, over 300 liters of nutrient-rich water from the fish tanks travels through a pump out to the garden beds.

Plants are initially seeded in her greenhouse until she is able to transplant them into foam trays in the outdoor beds. The trays force the roots to grow down so they can reach the water flowing below. Wall is able to grow about 3 kilograms of leafy greens a week, including bok choy, buckhorn and spinach.

The ammonia-rich water provides nutrition for the roots, then is filtered, oxygenated and pumped back to the fish tanks in the basement. From this final stage, the cycle repeats itself.

Wall uses her produce to make salad arrangements for Mountain Shadow Greens, which distributes produce to markets in Port Angeles. Today she is only growing leafy greens, but she plans to diversify her product in the future. Through trial and error, Wall hopes her experience will show the Port Angeles community the importance of growing their own food.

Tending her plants, Wall lifts the cover of a grow bed enclosure, smiles and laughs. "It's like only God would come up with something so perfect." 

SARAH CLIMACO is a public relations senior who embraces the environment through photography. She gets fired up about sharing stories through her photos.
Samuel Wasser was exploring a remote rain forest in the northern part of the Selous Game Reserve in Morogoro, Tanzania, when he discovered two elephant corpses. The Selous Game Reserve is a hotspot for elephant poaching. One carcass was of a fully-grown elephant with poachable tusks. The other was a baby.

"WHAT BECAME CLEAR was they shot the baby so the mother would come back and then they shot the mother," Wasser said.

Wasser, a biologist at the University of Washington, developed a new method of combating elephant poaching by tracking the source of the ivory using elephant scat. Theoretically, using this method to reduce poaching should be easy because it would allow law enforcement to focus on only two key poaching sources. In reality, enforcing poaching laws is far from easy.

Illegal wildlife trade has become the world’s fourth largest transnational organized crime, and African elephant ivory is a major part of that trade, according to a 2014 article by Wasser.

In 2013, more than 40,000 kilograms of ivory was reported seized worldwide. It has been estimated the number of elephants killed in 2013 could have exceeded 50,000 out of an estimated 434,000 African elephants left. At this rate, this keystone species could decline rapidly, according to Wasser’s article.

Wasser created a genetic map of the forests and elephants in the different parts of Africa using samples of elephant dung found throughout those areas. He then took DNA from samples of ivory and compared them to the map to pinpoint the home of the elephants being poached.

“I don’t think there’s any other method out there that can do this in such a straight-forward manner as analyzing these large ivory seizures,” Wasser said.

This genetic material from elephant dung was readily available and the comparison led to an interesting insight. A majority of the ivory samples—which came from multiple half ton-plus seizures bearing the signature of organized crime—were from two distinct locations: southeast Tanzania and northern Mozambique.

Different methods of poaching have been uncovered through many field studies. Reports from 2011 by The Ruvuma Elephant Project, an animal conservation project in Tanzania, included photographs of elephants shot, poisoned or beaten to death with spiked clubs.
“Some of the worst forms of poaching have been poisoning water holes with cyanide or where they’ve put poison inside pumpkins. They kill collateral species too. Vultures eat poisoned carcasses and die. Then there’s direct shooting. The poachers are well-equipped and well-funded,” Wasser said.

There have also been incidents where poachers have come close to tourist camps, suggesting most other places have few elephants left.

“This is the last place they come,” said Malcolm Ryen, chief ecologist of Essential Destinations, an ecotourism organization for Tanzania.

A 2010 report by the Environmental Investigation Agency found few prosecutions follow convictions of illegal ivory trade, hinting at potential government involvement in both poaching and trafficking.

Poaching is driven by the demand for ivory in China and Southeast Asia, said Sarah Day, director of The Wildlife Connection in Tanzania.

In 95 percent of elephant poaching crimes, the poachers hadn’t removed any of the meat. Instead, the rotting corpses were left with their faces mutilated from having the tusks removed, according to a 2013 article published by PAMS Foundation, a conservation foundation in Tanzania.

“Some of the worst forms of poaching have been poisoning water holes with cyanide or where they’ve put poison inside pumpkins. They kill collateral species too. Vultures eat poisoned carcasses and die. Then there’s direct shooting. The poachers are well-equipped and well-funded,” Wasser said.

Efforts to decrease ivory demand were weak, as elephant conservation was lacking support in local communities. People were easily recruited to poach, and in many areas, there was no incentive to protect elephants. There’s actually incentive to kill them, she said.

Day began an outreach and education campaign in the villages bordering Ruaha National Park in Tanzania. People were surprised to hear elephants were being poached at such high volumes because they had no experiences leading them to believe so, and no access to information telling them otherwise, Day said.

The people saw elephants were still raiding their farms and assumed they would be around as they had always been, she said.

“They need to understand that it’s a problem and how they’re empowered to stop it. And most importantly, why they should,” Day said.

Wasser is currently working to get the most recent ivory seizures to see if government restrictions prompted by this research have caused any shifts. He also wants to see if the poachers have moved, so law enforcement may change combat strategies.
Dr. Samuel Wasser is a biologist at the University of Washington whose research has illuminated networks of ivory trafficking and illegal elephant poaching. He has pioneered a method of pinpointing the origins of elephant DNA in ivory seizures across the globe by comparing it with DNA from elephant dung samples in Africa.

“Sam’s work is incredible because he has this huge genetic population across Africa and he’s helping to link these massive seizures with individual killing fields, and if you knew how many elephants were being killed in one area at a time, you could pinpoint how this ivory was being moved and ultimately where these elephants came from,” said JJ Kelley, a documentary filmmaker.

Poaching is still prevalent in these two areas, despite Wasser’s efforts.

“Even now, if you look at recent articles in Tanzania, it was said we did not lose 12,000 elephants in Ruaha. They just kind of walked off, migrated. That’s impossible. Where do they migrate? How do they lose 12,000 elephants to migration?” Ryen said.

Ryen said Wasser’s work confirmed the census in Tanzania that displayed declining elephant populations that no one had believed.

The problem with solving poaching, Wasser said, is it’s a complicated issue.

“There’s just so many ways it’s impacting things: the ecology of these ecosystems, the economies of some of these countries that depend on elephants for tourism, and national security with insurgents poaching animals,” he said.

Elephant poaching has evolved to much more than tourists looking for a pretty souvenir from their time in Africa, Ryen said. Now, poaching is a major business, and those profiting don’t want to give it up.

“[Elephants] are extremely intelligent and extremely social animals,” Wasser said. “It’s unimaginable that these people just have no conscience about this.”
The Act Represented

The culmination of a $7 million investment split between the Washington State Department of Commerce’s Clean Energy Fund and Avista Corp. Inside two rows of shipping containers are an array of batteries that can store one megawatt of power, enough to power 750 homes for a little over three hours. The battery array’s implications are big. Without a battery, energy generated by a wind turbine or solar panel that isn’t immediately used by consumers is wasted.

Renewable energy resources are expected to account for 33 percent of global capacity in 2040, according to the International Energy Agency’s 2014 World Energy Outlook. Large-scale energy storage would allow turbines to continue generating power all night, and solar panels to collect usable power whenever the sun is shining. Then, when the wind stops blowing or clouds cover the sky, power can be released into the grid for consumption. The project in Pullman hopes to answer what the storage will look like.

To achieve meaningful carbon emission reductions, the capacity of bulk energy storage in the U.S. needs to more than triple, according to David Keith, professor of physics and public policy at Harvard University. The system in Pullman is one of a host of technologies in the race to make a meaningful dent in achieving that capacity.

UniEnergy Technologies, the manufacturer of the batteries being tested in Pullman, is housed in a small commercial building off a quiet street in Mukilteo, Washington. The company was founded in March of 2012 by two former researchers at the federal Pacific Northwest National Laboratory.

The guts of the batteries still in production were spread throughout the large workshop at the facility, waiting to come together in their shipping container shell. Tall arrays of spiraling plastic pipes sat next to white plastic tanks nearly 23,000 liters in volume that would eventually be filled with liquid electrolytes.

“It’s like building a cross between a dishwasher and a battery, and you really don’t want it to leak,” said David Ridley, director of Electrical Engineering at UniEnergy Technologies.

In a redox flow battery, positively and negatively charged ions are separated and stored in tanks of liquid electrolytes.

“You can think of it as putting gas in your gas tank, basically. You’re putting electrons into tanks, and pulling them back out when you need them. Because there’s no chemical reaction, there’s nothing to fail,” said Curt Kirkeby, senior electrical engineer for Avista Corp.

While the redox flow battery technology on display in Pullman is highly advanced in terms of its chemistry and materials, there are other players in the energy storage market that take a low-tech, but potentially cost-effective approach.

One system pumped-storage hydroelectricity, generally referred to as “pumped hydro,” functions by pumping water uphill in times of excess energy generation, and letting it flow downhill to generate energy.
during periods of high demand. Compressed air energy storage functions similarly, pressurizing tanks or a cavern with air, then releasing the air through a turbine when demand increases.

Dr. Charlie Barnhart, assistant professor at the Western Washington University Institute for Energy Studies, has spent his career trying to figure out how to compare different energy storage systems. Barnhart compared the costs of geologic storage technologies and chemical-based batteries, including the vanadium redox flow technology being used in Pullman.

The study relies on net energy analysis. To describe the concept, Barnhart uses the analogy of a fox trying to catch a mouse as a meal. The fox must get more calories from the meal than she spent chasing the mouse or she will starve to death. The same holds true for energy.

“We need to get more energy back from our energy resources than we put in to try and harvest those energy resources,” Barnhart said. “It turns out efficiency losses are pretty important.”

When looking at the amount of money spent on a battery over its entire lifespan, a lithium ion battery is three times more cost-effective than a vanadium redox battery, and pumped hydro is closer to 100 times more cost-effective than a vanadium redox battery.

There were 40 pumped hydro plants operating in the U.S. in 2013, totaling roughly 2 percent of the country’s generating capacity and 22,000 times the capacity of Avista Corp.’s battery system, according to the Energy Information Administration. Many of the plants are over 40 years old, giving an advantage in longevity over the redox flow battery.

The problem, Barnhart said, is geographical.

“You need two giant holes in the ground separated by less than a 1.5-kilometer horizontal distance and at least 300 meters vertical distance,” he said.

Such geography is easy to find in the Northwest, but non-existent in the middle of the U.S. and many other flat parts of the world.

In Ontario, Canada, local geology may allow the city to implement a compressed air energy storage system. A study for the Ontario Power System by Andrew Ford in June 2015 projected that compressing air into salt caverns could store 1,000 megawatts and save the province $8 billion over 20 years.
For Barnhart, it’s still too early in the game to settle on any single technology. “The more we learn about energy storage technologies, the more we promote them from a fundamental research and development perspective, they will only get better,” he said. “That is a good thing, something I certainly support.”

ANDREW WISE is a junior from Denver, Colorado, studying environmental policy and journalism at Western Washington University. He is dedicated to documenting the unique environmental issues of the American west.

ANNA KERR is a fine arts major with a photography concentration. She hopes to pursue a photojournalism career and cover social and environmental issues throughout the world.

LOWER LEFT: Parts of batteries housed within large shipping containers at UniEnergy Technologies in Mukilteo, Washington. Collectively, the containers can store one megawatt of power. The batteries can collect power during periods of low grid demand and release it during periods of high grid demand. Without storage, renewable energy production that exceeds the grid’s demand is wasted.

Dr. Charlie Barnhart, assistant professor at Western Washington University’s Institute for Energy Studies, stands in front of his plans for a battery capable of storing large quantities of energy.

But he doesn’t expect energy storage to be integrated into the grid anytime soon. In the short term, Barnhart expects energy storage systems like the one in Pullman to power remote mining operations or bring electricity to isolated villages in the developing world.

In terms of capitalizing on the projected increase in renewable energy generation, Barnhart offered another option: putting excess energy to work for valuable tasks without time-sensitive constraints, like desalinating water or purifying metal ores.

“In a sense, energy would be stored all throughout the economy, rather than on the electrical power grid,” he said.

In the meantime, the electrons will continue to flow in and out of the batteries in Pullman. The Pacific Northwest National Laboratory is in the process of monitoring their performance and two other Clean Energy Fund storage systems, both lithium ion systems, in Everett, Washington and Glacier, Washington. That data will likely be published in June 2016, Kirkeby said.

For Kirkeby and Avista Corp., the project is about trying to figure out what role energy storage can play in utilities as the grid continues to evolve in terms of both power generation and delivery.

“The costs will continue to come down, and it could be redox flow is replaced by something else,” Kirkeby said. “It’s more about understanding what we need, how it operates and how to maximize return. Then the costs take care of themselves with the benefits.”
APPLE AUTOMATION

WASHINGTON PRODUCES OVER two thirds of the apples consumed in the U.S., and tree fruit has been the most profitable crop in the state for decades. But with a continually shrinking migrant labor pool and increasing market demands from overseas, the apple industry has struggled to keep up in recent years, despite record-setting crop yields.

To meet these challenges, farmers, entrepreneurs and scientists are looking to a new generation of automated and semi-autonomous technology to reinforce, and someday perhaps even replace, the lacking labor force in the state’s largest agriculture business.

DRONES OF THE DEEP

OCEANOGRAPHERS, MARINE BIOLOGISTS and any other scientists who deal with the big blue will say they could spend their whole life on the water and still not see all there is to see. But what if years worth of data across thousands of miles of ocean was available without even setting foot in a boat?

Autonomous underwater vehicles represent decades of marine technology advancement and offer a variety of solutions to problems facing marine scientists today at a fraction of the cost of many more traditional methods.

THE METRIC SYSTEM

The Planet, an independent publication rooted in science, has switched to the metric measurement system because it is widely used in scientific literature. Constantly converting from the imperial system is difficult, so see our table of common references online at theplanetmagazine.net/metric-system.
"Those who dwell, as scientists or laymen, among the beauties and mysteries of the earth, are never alone or weary of life."

RACHEL CARSON
AUTHOR OF "SILENT SPRING"