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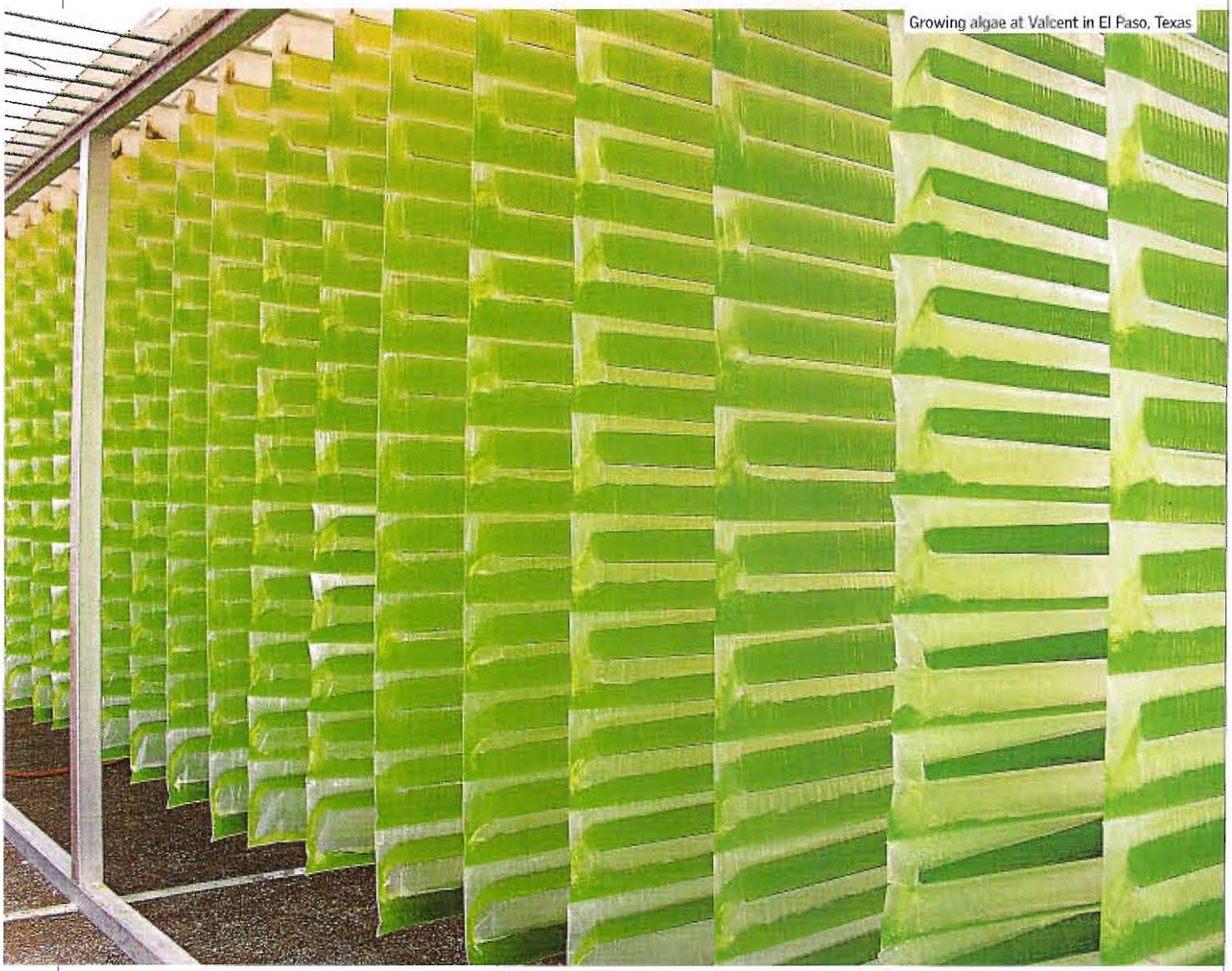

Growing algae at Valcent in El Paso, Texas

One Word: ~~Plastics~~ Algae

Pond scum might turn out to be the world's best source for, well, saving the world. By Heather Millar

WHEN IRA LEVINE, PHD, told his mother he was leaving medical school to become a phycologist, she didu't protest at first. But when she realized her son was going to spend his career analyzing algae, not the neuroses of affluent clients, she didn't speak to him for a year. If only Mrs. Levine could see her son now.

Algae — pond scum, kelp, seaweed, and the like — is enjoying a heyday. Scientists and entrepreueurs now tout it as much more than the nori that wraps your sushi or the carrageenan that thickens everything from ice cream to toothpaste. It could be the biofuel feedstock that saves the world without raising food priees, a vacuum that sucks up globe-warming carbon dioxide, and even a material that makes bioplastics, which disintegrate into compost rather than stick aronnd for eternity.

"It's kind of refreshing," says Levine, an associate professor at the Uuiversity of Southern Maine and an expert ou the commercial cultivation of algae. "People call me up. Ven-

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OriginOil's patented system for growing algae

ture capitalists take me out to dinner. They fly me around the world to speak. It's the first time that being a phycologist is cool."

In the last year or so, algae has gained two national organizations: the National Algae Association (NAA), aimed at helping startnps and what are called "algaepreneurs," and the Algal Biomass Organization (ABO), focused on pooling peer-reviewed research on algac as a feedstock for biofuels.

According to NAA fonnder Barry Cohen, attendance at thc NAA's quarterly workshops in Houston has been doubling every three months, with 250 people present at the last session. When the ABO had its first summit in San Francisco last Novembcr, organizers planned an invitation-only session for 100 people, and 360 attendees from 20 countries showed up. At this year's summit, held in Seattle in October, attcudance nearly doubled with 670 people showing up.

"We're getting interest from all over the country, all over the world," Cohen says. "Just from the Department of Energy, it's

a $6 billion market. That's just the biofuel side. That's not including plastics and all the other things."

TO SOME EXTENT, this is an "everything old is new again" story. Algae — a huge family of more than 30,000 organisms that photosynthesize sunlight but lack roots, shoots, and leaves — grows quickly, with some species nearly douhling in volume overnight. And nearly half the body weight of some species may be lipids, the scientific term for oil. There's evidence that humans have used algae for millennia: Chinese texts from 5,000 BC mention it, and Irish farmers once fed it to their cattle.

Today, companies, led by firms in the United States, Germany, and Israel, already commercially grow about six microalgae species for food, cosmetics, and pigments. In addition, firms all around the world grow macroalgae for thickeners, farmed fish feed, dental molds, adhesives, ulcer medicines, etc. But while these products command generally high prices, their markets have limits. The world only needs so much algae moisturizer or algae-thickened ice cream, after all. When the talk turns to biodiesel and bioplastics, though, that takes things to a whole new level.

The idea to use algae in a fuel capacity was first tested about 50 years ago, when Massachusetts Institute of Technology scientists experimented with growing algae for biofuel. Then, in the 1970s, the Department of Energy spent $3.3 million to establish its Aqnatic Species Program (ASP), which was eventually shnt down in 1996. The problem was finding a cost-effective way to grow the algae on such a massive scale in the lab — like how to deliver just the right amount of light, among other things — as well as a cheap method for extracting the oil. Using organie solvents or just squeezing the oil out of the algae is a pricey business. But 30 years ago, when President Jimmy Carter first funded the ASP, a gallon of gas cost about 70 cents. Today, the math looks very different.

"At $10 to $20 a barrel of oil, algae is tough to bring to market," says Thomas Byrne, secretary of the ABO. "If petroleum is at $50 to $60 a barrel, that's very different. We think algae will be competitive."

What's more, algae boosters say, new technologies like closed hioreactors promise to

make it easier to grow acres of algae in mass quantities. Plns, algae also can be grown in wastewater, uses carbon dioxide as it grows, and produces fewer hydrocarbons when burned, providing a hedge against climate change, which is a huge benefit. The cost of getting the oils out of the algae is dropping as well, now that scientists have a much better understanding of algae's fat-producing cycle: Starving it actually makes it produce more fat. This means companies can hold off on thc food at the end and then harvest the organisms at their fattiest.

"It cost $10,000 three years ago to produce one gallon of algae gas, $3,000 in 2006, and $20 this year," says Will Thurmond, chairman of research and development for the NAA. "The cost curve is dropping rapidly."

Of course the major money — and hype — has poured into algae biofuel. Bill Gates just invested in the San Diego start-up Sapphire Energy, which intends to make anto fuel from algae and then expand into developing gasoline eqnivalents like diesel and jet fuel.

Airbns and Honeywell recently announced that thcy're developing a jet fuel by using vegetation- and algae-based oils. By 2030, they hope to power a third of commercial aircraft this way. And a variety of other companies, including Boeing, Chevron, and Royal Dutch Shell, are also looking into algae's potential.

"The yield is much higher than anything else we know of, and it's not competing with food sources," says Bill Glover, director of environmental strategy for Boeing Commercial Aircraft. "We want people to enjoy commercial aviation with a clean-energy solution. This is a way to do that."

Estimates on when airliners might widely use algal jet fuel vary, ranging from threc years to more than a decade. Fnel mixes that incorporate algal biofuel will likely make it to market first. Boeing has predicted that a fifty-fifty mix of algal biofuel and petroleum jet fuel could be available early in the ncxt decade, but, Glover says, such mixes may not power the world's entire air fleet until 2025, simply because of the difficulty of creating the infrastructure to grow and process that much biofuel.

Companies are already taking the first real steps in that direction, though. In February 2008, the start-up Solazyme, hased in San Francisco, produced an algal

biofuel that in tests behaved just like jet fuel derived from petroleum: It didn't freeze at the low temperatures of high altitudes, and it passed all the government testing specifications for aviation turbine fuel.

BY READING THE WEBSITES of various start-ups, you find that an acre of algae can possibly produce 100,000 gallons of fuel in a year — or maybe it's 30,000 gallons or 4,000 gallons or 400 gallons. Yet even the lowest figure, scientists say, compares favorably with the 50 gallons that an acre of soybeans produces.

The challenge is that algae can be finicky. Too much light or too little, and algae stops producing. Too hot or too cold, and again, algae stops producing. Wrong nutrients or too many nutrients, same thing. Invasive species can overwhelm the desired species, contaminating the whole batch. And when you grow a large amount of algae, the cultures eventually get so thick that it blocks light, preventing the optimal growth of more algae.

Various companies have come up with ingenious solutions to these problems. Solazyme grows algae in dark fermentation tanks, feeding it sugar. Valcent, in El Paso, Texas, grows algae in slowly moving vertical plastic bags that hang from a turning rod; this allows light to get in from every angle. Other companies grow it in plastic rods or triangular chambers. OriginOil, in Los Angeles, has patented a system with a vertical shaft that rotates very-low-energy lights in a helix pattern. And then there are companies like PetroSun, in Rio Hondo, Texas, and LiveFuels, in San Carlos, California, that stick to the old-fashioned method: They simply grow the algae in large ponds.

Several firms are also betting that the oils from algae might replace the petrochemical oils used to manufacture plastics. Researchers at the University of Texas at Austin have shown it's possible, and PetroSun is using some of the algal oil from its farm to conduct bioplastics research. The European Union has also funded research into algal bioplastics.

"We're getting tremendous interest from plastics companies — some really big companies — that want to go over to green plastics," Cohen says. "No one's [gone] public yet, and it's still in the research stage, but algae plastics and algae packaging are coming."

The first step to any of this, though, is getting the algae oil. Companies such as Sapphire and Solazyme put the time horizon for their products at three to five years, but experts say it may be 10 years before the supply of algal oil is large enough to be felt in the market. Still, Solazyme's biodiesel (Soladiesel) was tested in military trucks in April, and a Chicago chemistry teacher and his class of 140 students managed to produce enough algae biodiesel to drive a Volkswagen Vanagon to the Sears Tower from Al Raby School for Community and Environment on the West Side. And if a class of chemistry students can make it happen, then the rest of the world can't be far behind. AW

Brooklyn, New York–based writer **HEATHER MILLAR** is a frequent contributor to *American Way*.