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Algae: The next biofuel bet

Hundreds of millions of dollars are being spent on pond scum as a future source of renewable energy

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Algae, it appears, are the new green in the quest for a sustainable biofuel that can run cars, put airplanes in the sky and be made into shopping bags.

Paul Woods was 22 and studying genetics at the University of Western Ontario when he realized that under certain conditions some species of algae naturally produce small quantities of ethanol.

It was 1984, oil prices appeared to be heading higher, and Woods wondered whether pond scum could be genetically engineered to produce large volumes of the renewable fuel as an alternative to gasoline. The Toronto-born biology student needed some expert advice, so he tracked down plant biologist John Coleman at the University of Toronto and laid out his wish list.

"He basically walked into my lab and asked, `Do you think this is a possibility?' " recalls Coleman, a senior professor in the university's department of cell and systems biology. "I sat down, thought about it for a little while, and we started coming up with more ideas."

Twenty-five years later, Woods, now 47, is founder and chief executive of Florida-based Algenol Biofuels and Coleman is its chief scientific officer. No longer are they just mucking around in the lab. Algenol announced last month a partnership with chemical powerhouse Dow Chemical to build and operate a demonstration algae-to-ethanol plant at one of Dow's manufacturing sites in Texas.

Algae, it appears, are the new green in the quest for a sustainable biofuel that can run cars, put airplanes in the sky and be made into shopping bags. Dozens of start-ups have sprung out of universities, government labs and corporate R&D divisions, all hoping to break the world's addiction to oil in a way that's economical and doesn't compete against food production. More significantly, corporate titans – Dow Chemical just one among them – are entering the game.

It came as a surprise earlier this month when ExxonMobil, the world's largest oil company,

said it would invest $600 million (U.S.) to research and develop algae-derived oil, and possibly billions of dollars more to commercialize a product.

Honeywell International, through its subsidiary UOP, has been working with Boeing, Airbus and major airlines since 2008 to create a new kind of jet fuel derived from algae oil. Its process was developed under contract with the U.S. Defense Advanced Research Projects Agency to create renewable fuels for the military. The green fuel was successfully tested last month on two engines used in small jetliners.

Algenol is keeping its focus on ethanol. It has developed strains of blue-green algae – also known as cyanobacteria – that are genetically enhanced to create sugars when exposed to sunlight and carbon dioxide. Enzymes within each microbe have been boosted to convert as much of the sugar as possible into ethanol, which naturally seeps out of the algae cells and is collected.

Dow plans to populate its 24-acre site in Texas with 3,100 "photobioreactors," horizontal chambers about 1.5 metres wide and 15 metres long. The algae would be "fed" a constant stream of CO2 pumped in from a neighbouring Dow chemical facility. The algae would grow in salt water within the reactors, each capable of holding 4,000 litres.

The goal: produce 380,000 litres of ethanol a year. Dow can use ethanol to replace fossil fuels in the production of ethylene, a chemical feedstock for the manufacture of plastics. Andrew Liveris, chairman and chief executive of Dow, calls the initiative a "ground-breaking alternative energy project."

The wave of interest has been a long time coming, says Woods, calling the work he and Coleman did during the 1980s and 1990s a "glorified hobby" with little market value at the time. Oil prices began falling again in the late 1980s and the concept of "peak oil" was on hardly anyone's radar screen. Woods couldn't sit back and wait for a market to emerge; he had to get on with making a living.

In 1989, he ended up forming Toronto-based natural gas marketer Alliance Gas Management, one of the first companies in Ontario to take advantage of market deregulation. It grew to 300,000 customers before being merged into Direct Energy in 1999. Woods then moved to the United States and founded a similar company called United Gas Management, which ran into financial troubles and was sold. All the while, he was working on the algae-to-ethanol project on the side.

It wasn't until oil prices started to creep up again and climate-change issues began to grab headlines that he saw an opportunity with algae.

In the spring of 2006, he decided to formally establish Algenol as a company.

"It was a confluence of events," he recalls. "You had high oil prices, renewed value in fresh water, and a real concern about CO2 emissions. It was really only algae that could address those issues broadly and directly."

Not that the road ahead will be easy. It's no secret that biofuels – whether ethanol or biodiesel – have gotten a bum rap over the past two years. Most of the ethanol produced in North America today comes from corn, and a fierce debate has emerged over whether prime agricultural land should be used to grow crops for fuel instead of food. Many researchers have also questioned whether corn-based ethanol, taking into account the energy required to grow, harvest and process the corn, offers enough of an energy and environmental payback to make it worthwhile.

The rush to produce biodiesel, meanwhile, has seen rainforests cut down in Indonesia to make room for palm plants. It's a classic case of unintended consequences that some scientists call an ecological disaster. But biofuels themselves aren't the problem, which has more to do with how they're produced, and that's why algae have re-energized interest in this emerging market.

Many algae species can grow in salt water, so there's no draw on fresh water – in fact, fresh water is often a useable by-product.

Algae production doesn't compete with food, and it doesn't require prime agricultural land to grow. By some estimates, it uses one-tenth the land required for growing corn. The biggest challenge is to develop an approach to producing oil or ethanol from algae that can be done at a competitive cost on a massive, global scale.

Most methods to date involve continually growing algae in large open or closed ponds. The algae are then harvested and processed in a way that extracts the natural oils inside the microbe cells.

It's a costly, imperfect process that has hobbled efforts at making the alternative fuel economical.

Better, argue scientists, to let the algae live and design them to secrete the oils or ethanol naturally – allowing us, in a word, to "milk" the algae like we do cows.

"We do not harvest milk from cows by grinding them up and extracting the milk," wrote theoretical biologist Richard Gordon, a professor at the University of Manitoba, in a recently published research paper about diatoms, a type of single-cell algae. "Instead, we let them secrete milk at their own pace, and selectively breed the cattle and alter their environment to maximize the rate of milk secretion. Perhaps we could do the same with diatoms."

Algenol is doing exactly that, but it's not alone. Catilin Inc. of Iowa is taking a similar approach, but like most others is focusing on oil production instead of ethanol.

Exxon, which spent two years searching the world for the best biotechnology partner, ended up hitching its wagon with California-based Synthetic Genomics Inc., whose famous founder Craig Venter has engineered algae cells to secrete oils that are good enough to drop into a refinery with other petroleum streams.

If anyone can perfect the process, it's Venter, the man credited for first sequencing the human genome.

"This is the largest single investment in really trying to produce biofuels on a global basis right now," Venter said at a recent conference with Emil Jacobs, vice-president of R&D with ExxonMobil research and engineering.

Venter says the effort is just as much about macro-engineering as it is micro-engineering of algae. Exxon's role will be crucial if there's any hope of economically taking the oil produced from algae and dropping it into existing petroleum-industry infrastructure. Integration with today's refineries and pipelines will be key to achieving global scale.

"This would not happen without the oil industry stepping up and taking part," he says.

At the same time, Jacobs warned that the excitement around Exxon's involvement should

be tempered by a healthy dose of reality.

"This is not going to be easy and there are no guarantees of success," he says.