S2 Ep4: The Mean, Green, Water-Cleaning Machine

[Intro music]

Tony Cohn: This is Sidedoor. A podcast from the Smithsonian with support from PRX. I'm Tony Cohn. Back in May, I visited the Port of Baltimore. It's this large, high traffic port that is one of the largest in the country for cars, farm equipment and that kind of thing. The port takes up 45 miles of shoreline along the Patapsco River.

[Ambience sounds]

Peter May: And here you see the sea of cars behind us.

TC: I'm here with Peter May.

PM: I'm Dr. Peter May. I'm a senior environmental scientist with the Baltimore-based ecological engineering firm bio habitats and I'm also a lecturer at the University of Maryland College Park in the Environmental Science and Technology program.

TC: And I want you to really imagine an ocean of cars. Parking lots filled with cars that stretch for miles or like maybe "*a"* mile. But still – it's a lot of cars. And, when we imagine pollution created by cars, we usually think about the air. Carbon dioxide. But cars also cause problems for oceans, lakes and rivers.

PM: Cars drop little bits of metal and oil and grease and those things are part of that whole polluting load that goes onto a parking lot, that when it rains, it gets swept off into the harbor. Really the water quality in the harbor depends on which you know what day of the week that it most recently rain.

TC: Baltimore is a city surrounded by a lot of water: the Patapsco River, the Chesapeake Bay, and a lot of smaller lakes, reservoirs, and streams.

PM: So the port has a big parking lot, that when it rains, runoff from it contributes a certain amount of nutrients and sediment that go into the river.

TC: Nutrients and sediment… just think of those as "water pollution".

PM: And so they need to control that.

TC: And all of that concrete that surrounds Baltimore's waterways make its water pretty dirty.

PM: I've gone fishing in here and I've accidentally gone swimming. But it's something that there's a goal for Baltimore City to become swimmable, fishable in 2020 which is only a few years away.

TC: One part of the solution here in Baltimore?

PM: We're using the power of algae

TC: Yep. Algae. Even though you probably haven't heard of algae to as a way to clean the environment… it's not a new technology. In fact -- the technology behind this big water filter in

Baltimore has existed in various forms for decades. So -- why isn't this green technology everywhere? This time on Sidedoor, we're going to tell you the story of this algae-powered pollution solution and the persistent scientist who has spent more than 50 years making it all happen. So stick around. We'll be right back.

[BREAK]

Walter Adey: Algae are not the slimy things that most people think of. Some are. The vast majority are far more complex. They produce about half of the oxygen that gets into the atmosphere every day. So without the algae we would probably be short on oxygen.

TC: This is professional algae enthusiast Walter Adey.

WA: I've been a research scientist at the Natural History Museum since 1964. Officially retired in 2015 and now working as an emeritus.

TC: Years ago, Adey was a young botanist who was studying the mechanics of how an ecosystem works: He wanted to understand how all of the parts connect to each other.

WA: And in doing that I came upon this group of extremely important algae in the environment that were poorly known. And I started looking at them and found these extraordinary structures that had never been described before. That's how I wandered into algae, kind of by chance.

TC: So, next thing Adey knows, he's cruising around the Caribbean in a home-made 41-foot boat, studying coral reefs. And one day he was watching the waves wash over the coral reef.

WA: If you think of a wave breaking across a reef surface, the wave would come let's say every 12 or 15 seconds, would break and then would flow across the reef and then you get this little bit of a backflow. So it's a back and forth motion of the water

TC: And then BOOM! Suddenly. It occurs to Adey it's that back and forth motion of the waves that mixes up nutrients in the water, and delivers a fresh supply of food to the algae.

WA: I suppose the "Eureka!" moment was when a wave hit me and knocked me head over heels back across the reef.

TC: Without the waves to push more nutrients past the algae, the algae would absorb all of the nutrients from the immediate area. But with each wave comes more food, and with each back and forth motion, the algae has more opportunity to pull even more nutrients out of the water. The waves are like a conveyor belt that brings the algae its food.

WA: In growing any plants, you use fertilizer normally. And you keep adding fertilizer because the plants take the fertilizer up.

TC: In the wild, algae and other organisms in the environment keep chemicals, and each other, in balance. Nutrients like nitrogen, phosphorous and carbon help the algae grow. Algae is important because it forms the bottom of the food chain. Everything either eats the algae, eats the things that eat the algae, or eats the things that eat the things that eat the algae. You get the idea.

WA: Using an algal turf, as we know from coral reefs, you could basically take all of the nutrients out if that's what you wanted to do.

TC: So Adey found that it was THIS cycle

TC: The back and forth motion of the water, over the turfs of algae growing on the reef that was keeping the Caribbean waters so pure, and full of life. Eventually, Adey's Caribbean research dream job came to a close, but not his relationship with algae**.**

WA: I'd spent about five years in the Caribbean, roughly 1972 to '78. And it was time to come back to Washington. Usually you can't disappear forever. *Chuckles* I wanted to keep working on this issue. And so I needed to develop a coral reef aquarium, basically, was what I was thinking of, so I could bring the organisms I was working on back to the museum.

TC: It *sounds* like a pretty simple idea, right? Growing a coral reef in a lab. But back in the early 1980s, we didn't know exactly how the entire ecosystem worked. In order to grow healthy coral, Adey needed to understand how the water worked, how the fish were supported, and all of the chemicals involved. So the question Adey faced was, "How do you grow a fully functional coral reef inside a museum basement?"

WA: Well, to put a coral reef in an aquarium, you have to simulate a lot of physical chemical functions and that's pretty tricky, and it took a couple of years. From the point of creating the coral reef in a system and getting all of its components to do well

TC: This is an over-simplification, but basically, Adey's original coral reef aquarium had three main ingredients: The first one is obviously water.

WA: We brought water from the Caribbean with 5,000 gallon tanks and fill them up and bring them right up here to Washington. This was in the early days where we weren't sure what components were missing. So we preferred to have the water, if you will. Later on that was totally unnecessary.

TC: The next ingredient… just a dash of algae.

WA: There are wide variety of algae on coral reefs, but we're primarily talking about the small ones, the turfs that grow on the surface of the reef.

TC: And, of course, coral.

WA: You wouldn't think of a coral reef without stony corals. So it took a few years and eventually, we demonstrated how to grow corals. And the bottom line is that the algal turf is a scrubber.

TC: And "the algae turf scrubber" was born. In running his water over the algae turf, Adey was able to adjust the water quality to perfectly suit the coral's needs.

WA: So that led to this device called an algal turf scrubber which was attached to the reef and the water circulated from the reef aquarium through the algal turf scrubber and back to the

aquarium and by adjusting how fast the water flowed, you could adjust the level of productivity in the algal turfs. So you could adjust the quality of your water wherever you wanted it.

TC: Adey got so good at this, that he was able to create entire miniature ecosystems in the basement of the Smithsonian's National Museum of Natural History. His Caribbean coral reef aquarium was the simplest. But others, were very complicated.

WA: We did a rocky Maine coast for example and then we did a Florida Everglades and a Chesapeake Bay system with its whole range of salinity, from basically coastal water salinity, the all the way to fresh water.

TC: In his Everglades model, Adey thought of everything, down to having tree crabs live in the mangroves. And remember friends -- all indoors, downtown in Washington, D.C.

WA: As we learned with much larger systems for example - our Florida Everglades - that was a complex system all the way from saltwater to freshwater in the same system and we use these things called gates to separate the salinity sections. So it gets to be pretty tricky and it's more a matter of how much time and effort you want to put into it, and it gets to be about as difficult as understanding a wild ecosystem.

TC: Adey's aquarium construction was so good that his first functioning ecosystem -- the ORIGINAL algal turf scrubber, from the early 1980s is still alive after all this time, living out its twilight years down on Florida's Atlantic coast. We'll be back after a quick break.

[BREAK]

TC: In May, I was down on Florida's east coast, about halfway between Orlando and Miami in a place called Fort Pierce. Bill Hoffman manages a Smithsonian aquarium exhibit that runs on algae. Other than a few minor changes, the aquariums are the exact same ones that Walter Adey developed in Washington, D.C. And they run on the same technology. Hoffman worked on the aquariums in D.C. as well. When the Fort Pierce exhibit opened in 1999, they shipped Adey's original aquariums down to Florida in a truck, and Hoffman went with it.

TC on tape: I think my favorite one of my favorite parts of this story is that you followed this aquarium from D.C. all the way to Fort Pierce Florida.

Bill Hoffman: Yeah. I consider myself part of the package deal.

TC: To take a peek at the algae powered aquarium filter in action -- Adey's Amazing "Algal Turf Scrubber" -- Hoffman led me up this rickety ladder.

BH: The original algal turf scrubbers that Walter Adey first designed when he was trying to work out the technology, we still have here. We brought them down from Washington when we moved the exhibit here to Florida. The only thing we've changed is they now have LED lights, which are more energy conscious I guess.

TC: Up above the aquarium, the filtration systems look a bit like laundry machines, but instead of tops they have a screen that's covered with green goop. The screens are about the same size as a movie poster. So the way the turf scrubber works is, pumps send water from the

exhibit tanks up to the museum's "attic area" Then… the water flows over top of a bed of green turf algae.

BH: Very fine algae... it just looks like little hairs, like grass on a smaller scale. It grows very close together and forms a turf. And that's where Walter Adey coined the name algal turf scrubber.

TC: This algae in the aquarium filter works pretty similarly to algae in the wild -- water flows over the algae, unwanted nutrients in the water feed the algae and get pulled out of the water. The water is now clean and full of oxygen. But unlike in the wild -- there are no fish nibbling on this algae. When the algae gets too long, it absorbs fewer nutrients from the water. So Hoffman and his team have to mow the algae, to remove the waste and encourage the algae to keep growing.

BH: Literally like cutting the grass. We use this acrylic blade. And literally just scrape them down rinse them out a little bit just for the detritus of the dirt and the loose algae that's stuck in them. We can collect that algae that's packed with nitrogen and phosphorus lots of minerals. So it makes for a really good fertilizer. So basically we add food to our aquariums every day. Every week we take out a lump of algae.

TC: Back in the 1980s, Adey developed this technology and it worked well for aquariums. And he thought -- there HAS to be a way I can use this outside of aquariums. So he went hunting for problems for his Amazing Algae Turf Scrubber to solve.

[Music Bed]

TC: So let's just catch up on where we've been so far. Walter Adey was in the Caribbean studying coral reefs back in the 1960s and early 70s, when he discovered that algae and a wave's back and forth motion helps purify water on the reefs. Next, after a few years of research Adey figured out the key to having algae purify water indoors, to the point that he could recreate entire ecosystems in a museum basement, some as complex as the Florida Everglades. One of his first major tests of the turf scrubber on a large -- and very public -- stage was when Adey installed it in the Biosphere 2 project in the early 1990s. You might remember the *not very good* 1996 Pauly Shore movie loosely based on this project called "Bio Dome".

[Play "Bio Dome clip"]

TC: But the real Biosphere project was a pretty serious bunch. And they were interested in developing technology.

Patrick Kangas: They were really interested in developing technology that could foster space travel and colonization of space. And they were completely serious about this so it wasn't science fiction to them.

TC: That’s Pat Kangas. He’s an environmental science and technology professor at the University of Maryland. So the Biosphere team simulated what it would be like to live in a space colony in Mars by farming all of their food, including raising five goats, three pigs, 38 chickens and fish. There were also different simulated climate zones that let them grow dietary staples like wheat and rice, as well as vitamin-rich fruits like papaya and bananas.

TC on tape: Did people think that they were nuts?

PK: Yes they did. And there's been some some good books that have been written just recently that have really we're starting to hear the whole story of what happened out there.

TC on tape: Out there is where?

PK: It's in southeast Arizona near Tucson. And so it's in the desert. And so they built a closed system.

TC on tape: I’m picturing like a big bubble.

PK: It's like a big bubble. It's the size of an aircraft carrier. And you know part of it is above ground. And part of it is below ground and the part above ground has these natural ecosystems in them and so they had they had to they wanted to create natural vegetation forms like we have across the planet.

TC: In order to support all of that life -- people, animals and huge variety of food, they needed a lot of water. And since the dome was a closed system, they needed to be able to filter the water clean, and reuse it.

PK: They ended up hiring Dr. Adey to build both their ocean and their Marsh biome, a marsh biome being the Florida Everglades. So I went out last year we resurveyed the Everglades system that Adey built in the late 1980s and early 90s. It's still chugging along it's a beautiful mangrove forest. And even though it's not been maintained at all, he incorporated enough of the system there so that it's self-sustaining.

TC: And while the Biosphere project was chugging along, Adey looked for other places to prove his algae technology.

WA: We knew in Florida for example that the Florida Everglades was entering a serious nutrient problem, primarily from sugar farming. And so all the nutrients being used to grow crops was flowing into the Everglades.

TC: The extra nutrients were allowing certain types of grasses to grow out of control and totally change how South Florida's environment works.

WA: And the sugar companies were under a lot of pressure from the -- well the EPA, I guess, at that time. So we went to the sugar companies and one of the companies said, "Hey great idea. We'll fund you. We'll give you a grant to do this." So we did it. And it removed the nutrients beautifully. You couldn't ask for anything better. So we went back for a second grant. Through the Smithsonian, we put in a proposal to the good companies to do a larger system. Next thing I get a call from the Justice Department -- "we are suing the sugar companies and the state of Florida. We don't want the complication of the Smithsonian involved. So you can't take that grant and get out." So that was that.

TC: So Adey dusted himself off and found another project for his algal turf scrubber.

WA: So we developed this huge fish tilapia project in Texas.

TC: A fish farm.

WA: We had a seven acre ATS

TC: A-T-S--That's what Adey calls his algal turf scrubber.

WA: And we were producing hundreds of thousands of pounds of fish a year. And selling it to the markets. Well unfortunately there's a lot of tilapia produced in Mexico. Cheaper. And this was a totally closed system now; we didn't have to have any wastewater but it costs more than you know growing it in Mexico. So another one down.

TC: Basically, even though the algal turf scrubber works, a lot of companies avoid it for two reasons: either because it just costs too much to try and clean up after themselves, or governments and companies are afraid of it. It's too outside the box.

WA: It's been pretty frustrating.

TC: That was over the past 30 years. But today — for Adey and his algal turf scrubber there is finally glimmer of hope on the horizon.

[Music Bed]

TC: Which brings us to where we started, to the Port of Baltimore. This application of Adey's algal turf scrubber works in the same way that Adey's original turf scrubber does: pumps water over the top of a bed of algae, which pulls out the unwanted nutrients, and puts the newly cleaned water back into the Patapsco River. But compared to the movie-poster sized filters Adey made for his museum aquariums, this one is much bigger. It's almost 200 feet long, and 6 and a half feet wide. Here's Peter May, the environmental scientist we met earlier.

TC on tape: It looks like a slip and slide.

PM: This is actually one of the most interesting elegant forms of ecological engineering that I think most people when they do look at it they say yeah this is a big slip and slide. It dumps the bucket and gravity is pushing water across the screen and that pulse is mimicking what Dr. Adey saw it in the Caribbean on the tops of coral reef heads right below the water surface. And so it increases production which means more pollutant removal like nutrients and sediment.

TC: Baltimore's water has a long way to go before it's clean enough for swimming and fishing. And the algae program at the Port of Baltimore is set to grow. It's still in the planning phase, but the new version of the A-T-S slip and slide could be as big as 5 acres. But even the small-scale algae scrubber has had a big impact. In the 310 days it has run over 3 years, it removed 40 tons of pollutants from the Patapsco River.

TC on tape: It just seems like such a simple, I don't know if that's right word, but it's such a simple solution to a great problem.

PM: Nature's had a very long time to come up with solutions and aspects to the ecosystems that we're only beginning to understand and learn about that we could potentially solve you know societal problems. And usually the best engineering is the simplest engineering and there's no better engineer in my mind than nature.

TC: Pilot programs are beginning to pop up around the country in places like Fort Lauderdale, Florida and Jamaica Bay, in New York City -- places, that because of government clean water regulations, have an obligation to clean up after themselves. And for Walter Adey, who is now 83 years old, it's the culmination of a lifetime of work -- and a chance to see his technology begin to have the impact he always thought it could -- methodically churning out clean water at a time we need it most.

[Credits]

TC: You've been listening to Sidedoor, a podcast from the Smithsonian Institution, with support from PRX. As you know Sidedoor is a pretty new podcast, so if you enjoyed this episode subscribe on the podcast app of your choice. We are on all of them. And tell someone about us. If you want to see some photos of the Agal Turf Scrubber in action, check us out at si.edu/sidedoor. We're supported in part by the Alfred P. Sloan Foundation: Enhancing public

understanding of science, technology, and economic performance. More information at sloan.org. Our podcast team is Justin O’Neill, Stacia Brown, Jason Orfanon, Gabe Kosowitz, Jessica Sadeq, Casey McAdams, Babara Rehm, Elizabeth Pilger, and I am your host, Tony Cohn. Thank you for listening.