00:04

For nearly a decade, my collaborators and I at the Self-Assembly Lab have been working on material systems that transform themselves, assemble themselves and adapt to their environment. From our early work on 4D printing, where we printed objects, dipped them underwater, and they transform, to our active auxetics that respond to temperature and sunlight, to our more recent work on active textiles that respond to body temperature and change porosity, to our rapid liquid printing work where we print inflatable structures that morph based on air pressure and go from one shape to another, or our self-assembly work where we dip objects underwater, they respond to wave energy and assemble themselves into precise objects like furniture.

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Or, at larger scales, using wind energy, we have meter-diameter weather balloons that assemble in the airspace above a construction site. For dangerous environments or harsh, extreme places where it's hard to get people or equipment, they can assemble in the airspace, and as the helium dies, they then come back to the ground, and you're left with a big space frame structure.

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All of this research is about taking simple materials, activating them with forces in their environment -- gravity, wind, waves, temperature, sunlight -- and getting them to perform, getting them to transform, assemble, etc. How do we build smart things without complex electromechanical devices?

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But more recently we were approached by a group in the Maldives, and they were interested in taking some of this research and ways of thinking and applying it to some of the challenges that they've faced in terms of climate change. And the first thing you do when you're approached by someone in the Maldives is say you want to go on a site visit.

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(Laughter)

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It is amazing.

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So we went there and I actually walked away with a really different perspective on the future of climate change. Because you would imagine, you know, the Maldives are sinking. They're screwed. What are they going to do? But I walked away thinking, they might be the model, the future model of the built environment, where they can adapt and be resilient rather than our fixed, man-made infrastructure.

02:07

But there's typically three main approaches to sea level rise and climate change. One of them is that we can do nothing and we can run away. And that's a pretty bad idea. As more than 40 percent of the world's population is living in coastal areas, as sea levels rise and as storms get worse and worse, we're going to be more and more underwater. So it's imperative that we solve this pretty demanding problem.

02:29

The second is that we can build barriers. We can build walls. The problem here is that we take a static solution trying to fight against a superdynamic, high-energy problem, and nature is almost always going to win. So that's likely not going to work either.

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The third approach is using dredging. So dredging is where you suck up a bunch of sand from the deep ocean and you pump it back onto the beaches. If you go to any beach around the Northeast or Western Coast, you'll see that they use dredging year after year after year just to survive. It's really not a good solution.

03:02

In the Maldives, they do the same thing, and they can build an island in a month, a brand new island they build from dredging. But it's really, really bad for the marine ecosystem, and then they become addicted to dredging. They need to do that year after year.

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But in the time that it took them to build that one island, three sandbars built themselves, and these are massive amounts of sand so big you can park your boat on it, and this is what's called a site visit. It's really hard work.

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(Laughter)

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In Boston winters. This is massive amounts of sand that naturally accumulates just based on the forces of the waves and the ocean topography.

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So we started to study that. Why do sandbars form? If we could tap into that, we could understand it and we could utilize it. It's based on the amount of energy in the ocean and the topography in the landscape that promotes sand accumulation. So what we're proposing is to work with the forces of nature to build rather than destroy, and in my lab at MIT, we set up a wave tank, a big tank that's pumping waves, and we placed geometries underwater. We tried all sorts of different geometries. The waves interact with the geometry, and then create turbulence and start to accumulate the sand so the sand starts to form these sandbars on their own. Here's an aerial view. On the left-hand side, you'll see the beach that's growing. In the middle you'll see the sandbar that formed. So these are geometries that collaborate with the force of the wave to build.

04:27

We then started to fabricate one. This was in February in Boston. We have large rolls of canvas. It's a biodegradable material, it's super cheap, easy to work with. We then sew it into these large bladders, and then we flew over there. And I know what you're thinking. This is not the Fyre Festival.

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(Laughter)

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This is real life. It's real. And we flew there with these canvas bladders in our suitcases, we got sunburned because it was Boston winter, and then we filled them with sand and we placed them underwater. These are exactly the same geometries that you saw in the tank, they're just human scale. Large objects filled with sand, we'd place them underwater, they're just really simple geometries. In the front of them, you'll see it's clear water. The waves are crashing over. It's quite clear. And then on the backside, there's turbulence. The water and the sand is mixing up. It's causing sediment transport, and then the sand is accumulating. You'll see some friendly stingrays here that visited us. On the left is day one, the right is day three. You'll see the sand ripples in the light areas where the sand is accumulating just after two days.

05:34

So this was last February, and it's very much ongoing work. This is just in the beginning of this research. Over the next year and longer, we're going to be studying this through satellite imagery and bathymetry data to understand what the short-term and long-term impacts are of natural sand accumulation in the environment. And the bigger vision, though, is that we want to build submersible geometries, almost like submarines that we can sink and float. Like adaptable artificial reefs, you could deploy them if there's a storm coming from one direction or another or if the seasons are changing, you can use these adaptable reef structures to use the force of the waves to accumulate sand. And we think this could be used in many coastal regions and many island nations around the world.

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But when we think about building smarter environments, think of smarter buildings or smarter cars or smarter clothing, that typically means adding more power, more batteries, more devices, more cost, more complexity and ultimately more failure. So we're always trying to think about how do we build smarter things with less? How do we build smarter things that are simple? And so what we're proposing at the lab and with this project specifically is to use simple materials like sand that collaborates with forces in the environment like waves to accumulate and adapt.

06:53

And we'd like to work with you, collaborate with us, to develop this, to scale it and apply this way of thinking. We think it's a different model for climate change, one that's about adaptation and resilience rather than resistance and fear. So help us turn natural destruction into natural construction.

07:12

Thank you.

07:13

(Applause)