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When Fashion is Fungal

Bolt Threads produced a golden Microsilk dress that was exhibited at the 2017 exhibition “Is Fashion Modern?” at the Museum of Modern Art. Microsilk is made in a laboratory from renewable materials that mimics the silk produced by spiders. (Bolt Threads)

By [Jessica Wolfrom](#)

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Fungus gets a bad rap. It renders our food inedible, our homes inhospitable and our toenails infectious. The word itself conjures up the notion of mold and decay — the slow ending of something alive.

But increasingly, scientists are using mycelium, the threadlike vegetative roots of fungus, to create everything from plastics to packaging materials to plant-based meats, even scaffolding to grow new organs.

And now, mycelium is starting to show up in closets as a nature-based material for clothes, shoes and bags slung over shoulders.

A new crop of manufacturers are harnessing mycelium to create leather-like materials without the cow. While their products are not yet on the mass market, they’re demonstrating that durable clothing and accessories can be derived from fungi — which is neither plant nor animal — at a lower carbon cost than traditional animal hides or plastics.

The fashion industry is the world’s second-most polluting business, behind oil, according to the United Nations. The industry consumes huge quantities of water and produces 10 percent of global carbon emissions — more than all international air travel and maritime shipping combined.

Not only does the production of textiles and leather pose environmental problems, so does their disposal. Fast fashion, inexpensive clothes frequently made from oil-based textiles that are designed to be worn briefly, has only compounded the problem. In 1960, Americans tossed 1,710 tons of textiles into landfills, according to the Environmental Protection Agency. By 2017, that amount ballooned to 11,150 tons.

### *[The troubling ethics of fashion in the age of climate change]*

Brands made from “biomaterials” are answering the call for greater sustainability, starting with how fabrics are made.

In 2007, when Sophia Wang became an assistant for Bay Area-based artist and sculptor Philip Ross, she had never considered fungi as a building material. But when she saw Ross’s sculptures, she said, “I was just blown away.”

Ross has been molding mycelium since the 1990s. He’s grown tables and chairs, and, in 2009, he constructed a teahouse out of mycelial bricks that was exhibited at the Kunsthalle Düsseldorf, the contemporary art exhibition hall in Germany.

Wang and Ross founded MycoWorks in 2013, and today they are growing a biomaterials company out of mycelium inside a lab in Emeryville, Calif.

“The process for growing it is pretty similar to what you would find with agricultural processes used to cultivate mushrooms, or as an analog, to create fine wines or cheeses,” Wang said.

MycoWorks coaxes mycelium cells from a wood-eating fungus species known as ganoderma to grow in a dense, intertwined structure to create a material the company called Reishi. (MycoWorks)

Reishi can be treated and manufactured like leather. (MycoWorks)

MycoWorks feeds agricultural waste such as sawdust to ganoderma, a wood-eating fungus species, to coax it to grow mycelium cells in a dense, intertwined structure. Left alone, this mycelium would form mushrooms, but by controlling temperature, humidity and other environmental factors, the mycelium instead produces sheets of fibers. The resulting product, which they’ve branded Reishi, can then be treated and manufactured like leather.

“Reishi is not leather. Reishi is more than leather,” said Matt Scullin, chief executive of MycoWorks. “We’re sort of limited by the vernacular right now. It feels like leather, it looks like leather, so we talk about it as leather, but it’s not leather.”

Tests show that Reishi outperforms leather in strength and matches leather in durability and appearance, the company said. Beyond being a viable material for fashion, it might provide a better solution for the planet.

“The leather and plastic-leather industries comprise one percent of global carbon emissions,” said Scullin. “I think the impact we can make with Reishi alone is actually quite significant.”

Outside the lab, fungi’s role in the carbon cycle might be more significant than previously understood. Studies show that when plants partner with certain types of fungi, they can store up to 70 percent more carbon in the soil, which contains more carbon than the atmosphere and vegetation combined.

### *[Storing carbon in the prairie grass]*

“When the carbon is broken down from these plant materials, there’s a large part of it that goes to making the fungus grow,” said Jonathan Schilling, a scientist and professor of plant and microbial biology at the University of Minnesota. “There’s a huge concentration of carbon that ends up resting in the soil, in this fungal biomass.”

Once a mushroom garment has reached the end of its life, it might be returned to the fungi that created it, in a perfect circle of recycling. “Some of the fungi can eat themselves,” said Schilling, who sits on the MycoWorks Scientific Advisory Board. “If you give them chunks of another individual fungus in their own species, they’ll eat that material.”

But Stephen Sothmann, president of the Leather and Hide Council of America, said it’s disingenuous for alternative leather brands to claim their products can save the lives of billions of animals or solve climate change. The U.S. leather industry maintains that it does not send a single animal to slaughter. Instead, it says, it exists primarily as a waste stream for skins and hides otherwise destined for landfills.

“The leather industry is a recycling industry,” said Sothmann. “We’re already taking a waste product and turning it into something sustainable and usable.”

Still, the leather industry is facing significant head winds. The public is starting to equate cattle with climate, raising objections to the greenhouse gases, land and water use and soil degradation associated with beef production.

In the past few years, plant-based meat replacements such as Impossible Burger and Beyond Meat have flooded the market. And research firms estimate that vegan leather, often made with petroleum, will grow significantly by the end of this decade.

“Frankly, we’re already in a nightmare scenario for the industry,” said Sothmann. He estimates that 17 percent of hides went to landfill in 2019 alone — a sizable loss for the industry.

But the biomaterials industry is on the rise.



In 2019, Stella McCartney and Adidas unveiled a tennis dress made from cellulose-blended yarn and Bolt's Microsilk, a protein-based material that is made with renewable ingredients such as water, sugar and yeast and can biodegrade at the end of its life. (Bolt Threads)

David Breslauer didn't set out to save the environment when he started Bolt Threads in 2009. But now he and his co-founders, Dan Widmaier and Ethan Mirsky, are working at the bleeding edge of material science, harvesting silk from sugars and "leather" from fungi.

"When I started looking into how spiders make silk," said Breslauer, "it turned out that they had this little microscale glandulature that secreted this protein that turned from a liquid into a fiber."

What started as three guys and an imitation spider gland is now a biomaterials company producing everything from "spider silk" to mushroom leather.

Bolt Threads takes organic material like corn sugar or sawdust and feeds it to yeast or fungus, which then convert it into materials used to make its Microsilks, which mimics the silk spun by spiders, and Mylo, which is Bolt's "leather" product, Breslauer said.

"Relative to a cow that takes years to grow, and then you slaughter it for its meat and skin, we grow Mylo in a couple of days," said Breslauer. "You can start really measuring how much better you are doing for the environment by finding an alternative."

Although humans have been cultivating animal skins for centuries, up until the 1800s, most hides were cured with excrement or dried in the sun. The Industrial Revolution ushered in new methods of chemically treating hides, introducing heavy metals and acids, like chromium salts and sulfuric acid, into the process.

Tanning, dyeing and treating skins can be chemically corrosive — harmful for the environment and human health. Beatrice Amblard, a master leatherworker of four decades, admits that "the tanning process is definitely not an ideal situation for the environment."

Investors have poured millions into bio-based textiles. Earlier this year, MycoWorks announced that it raised \$17 million in Series A financing and is expanding into a third commercial plant adding the capacity to produce 80,000 square feet of material per year.

MycoWorks debuted sheets of Reishi at New York Fashion Week in February and said partnerships with fashion brands will be announced in coming months.

Bolt, which raised \$213 million from investors including Formation 8 and Baillie Gifford, has tiptoed into the marketplace over the past few years, releasing limited-edition products like a Microsilks necktie priced at \$314 and a blended Rambouillet wool and synthetic spider silk beanie priced at \$198. It also partnered with Seattle-based Chester Wallace to release a driver bag in 2018, which debuted on Kickstarter at \$400 and sold out in seven days, a spokesperson for Bolt said.

In 2019, Stella McCartney, a brand that eschews leather and fur and promotes the idea that fashion can be gentle on the environment, unveiled a tennis dress made from Bolt's Microsilks and a Falabella purse made from Mylo, although not for purchase. A drapery golden Microsilks dress was also shown at the Museum of Modern Art's "Is Fashion Modern?" exhibition in 2017. Bolt's materials are

exclusively sold to Stella McCartney, but the company will be announcing other partnerships in the near future, a representative said.





## **Bolt Threads has also produced a body suit and trousers made from Microsilik. (Bolt Threads)**

Although it remains to be seen whether these products can safely biodegrade after manufacturing, Scullin says it's possible. "Under the right conditions, it will be biodegradable," said Scullin. But, he added, it will be up to brands that buy Reishi to be responsible stewards.

Despite its environmental downsides, leather remains popular. Last year, the United States exported over \$1 billion of cattle hides, pig skins and semi-processed leather, and the global market for animal leather was estimated at \$82 billion in 2016.

Although Sothmann said that the market has shrunk considerably since 2014, when this global data was compiled, he thinks leather, a natural material, is well-positioned for a future in which increasing emphasis is put on the circular economy, a system that eliminates waste through the continual use of resources.

For top fashion brands, leather still means luxury. Leather's durability, craftsmanship and buttery smooth feel are hard to compete against, but brands like Bolt and MycoWorks are betting their products can close that gap.

"I think we are going to grow the future," said Scullin. "We're not going to derive future materials from petroleum products, and we are not going to derive them from animal products."

Amblard is less convinced that mycelium will replace leather entirely, but she's excited to see new materials on the market. "We're going to get to a point where the look of mycelium will be very similar to leather, if not the same," she said. "I really think it's the way of the future."