



MATERIAL
INNOVATION
INITIATIVE

Brand Engagement with Next-Gen Materials: 2021

The Material Innovation Initiative is not a registered investment adviser (as defined in the Investment Advisers Act of 1940, 15 U.S.C. § 80B-1, et seq., and the rules and interpretations promulgated thereunder) and cannot transact business as an investment adviser or give investment advice. Any document or information created or shared by MII does not constitute advice concerning the value of any security or the advisability of buying, selling or otherwise investing in any security. The information provided in this report is for general information purposes only. All information in this report is provided in good faith, however, we make no representation or warranty regarding the accuracy or completeness of this information. If you would like to contact us about the contents of this report, please email info@materialinnovation.org.

First Mover Brands*

Creating with Next-Gen Materials

A

adidas
Alexander McQueen
Alexandre Herchcovitch
Allbirds
Allégorie
Apparis
Arkimedia
Asics Corporation
Audi

B

Bellroy
Bentley
Bergans
Bestseller
Bleed
BMW

C

Capri Holdings Limited
Chicco
Coilex
Covalent
Cubus
Culthread

D

Disney
Dotz
Doublet
Dyne

E

E. Marinella
etéreo

F

FAIRschuh
FitBit
Fossil
Fuchs Schmitt

G

Ganni
Genesis Footwear
Good Guys Don't Wear Leather
Gucci
Gus* Design Group

H

Hermès
Hilton
H&M
Horsefeathers
House of Fluff
Hugo Boss
Hyundai

I

iamoo
Infantium Victoria

J

Jacaranda
Jack & Jones
Jack Wolfskin
Jord

K

Karl Lagerfeld
Kazeto
Kering
Klättermusen
Komrads

L

Land Rover
Le Coq Sportif
Libena Rochova
Louis Vuitton
lululemon
Luxtra London

M

MA Allen Interiors
Maison Peaux Neuves
Marc O'Polo
Mārīcī
Marimekko
Marmot
Matt & Nat
Mercedes-Benz
Miomojo
Mochni
Modher
MoEa

N

Naot
Nike
Norrone

O

Oblique
Oroton
Other Stories

P

PANGAIA
Porsche
PVH

R

Ralph Lauren
Redemption
Reformation
Ricosta
Richemont
Roeckl
Roman Raibaudi

S

Salvatore Ferragamo
Samara

Sanabul
Save The Duck
Saye
Serapien
Skagen
Stella McCartney
Stüssy
Sylvén New York

T

Timberland
Thayer Coggin
The North Face
Tok Stok
Toyota Boshoku

U

Ugg
United Pets

V

Veerah
Volkswagen
Volvo
von Holzhausen

W

Windmillkey
Womsh
Woolly Made

Y

Yuima Nakazato

*This list contains brands mentioned in this report. It is not an exhaustive list of brands using next-gen materials.

Table of Contents

Executive Summary1

Part I: Introduction2

Overview

What Are Next-Gen Materials?

Why Use Next-Gen Materials?

Part II: Working With Next-Gen Materials16

A. Via Partnership

Next-Gen Leather18

Featuring:

• Ananas Anam

• Adriano Di Marti (Desserto®)

• Natural Fiber Welding

• VEGEA

• Frumat

• Fruit leather Rotterdam

• Hemp Black

• Nova Milan

• Zvnder

• Bolt Threads

• MycoWorks

• MYCL Mycotech Lab

• Ecovative

• Newlight

• Malai

• ScobyTec

• Panama Trimmings

• Toray

• Coronet

• Ultrafabrics

• Fiscatech

• Miko

Special: The Automotive Industry39

Next-Gen Down42

Featuring:

• PANGAIA

• Save The Duck

• 3M

• PrimaLoft

• Thermore

Next-Gen Silk46

Featuring:

• Orange Fiber

• AMSilk

• Bolt Threads

• Spiber

Next-Gen Wool51

Featuring:

• Spinnova

• Faborg

• EcoSimple

• Osom Brand

Next-Gen Fur56

Featuring:

• Ecopel

• Lenzing

B. Via In-House Material Innovation59

C. Via Investment61

Special: Real Leather Without the Cow

D. Via Providing Advisory Services64

Part III: Sourcing Tips65

Conclusion69

Executive Summary

The Material Innovation Initiative (MII) exists to accelerate the development of high performance, animal-free, and more sustainable materials for the fashion, automotive, and home goods industries. As part of this mission, we present the first-of-its-kind Brand Engagement with Next-Gen Materials: 2021. In this report, we bring together the what, why, and how of working with next-gen materials and offer tips to facilitate relationships in this rapidly growing and changing industry.

In Part 1, we provide our definition of next-gen materials and explain the reasons that more and more fashion, automotive, and home goods brands are choosing to integrate next-gen materials into their product lines. We present research on consumer demand, environmental impact, and animal-welfare issues to give an overview of current concerns in the industry.

The bulk of the report is Part 2: working with next-gen materials. We show four ways that brands work with next-gen material companies: partnerships, in-house innovation, investment, and advisory services.

Via partnerships

Capsule collections, co-branding, exclusive access - partnerships between brands and material innovators come in many shapes and sizes. This report features over 125 partnerships to inspire brands to work with next-gen materials and bring exciting new products to market.

Via in-house innovation

Some brands develop next-gen materials in-house to create those that best fit their needs and priorities.

Via investment

Brands can gain access to next-gen materials through investing in material innovation companies. We highlight some of the investments fashion, home goods, and automotive brands have made in the next-gen material space.

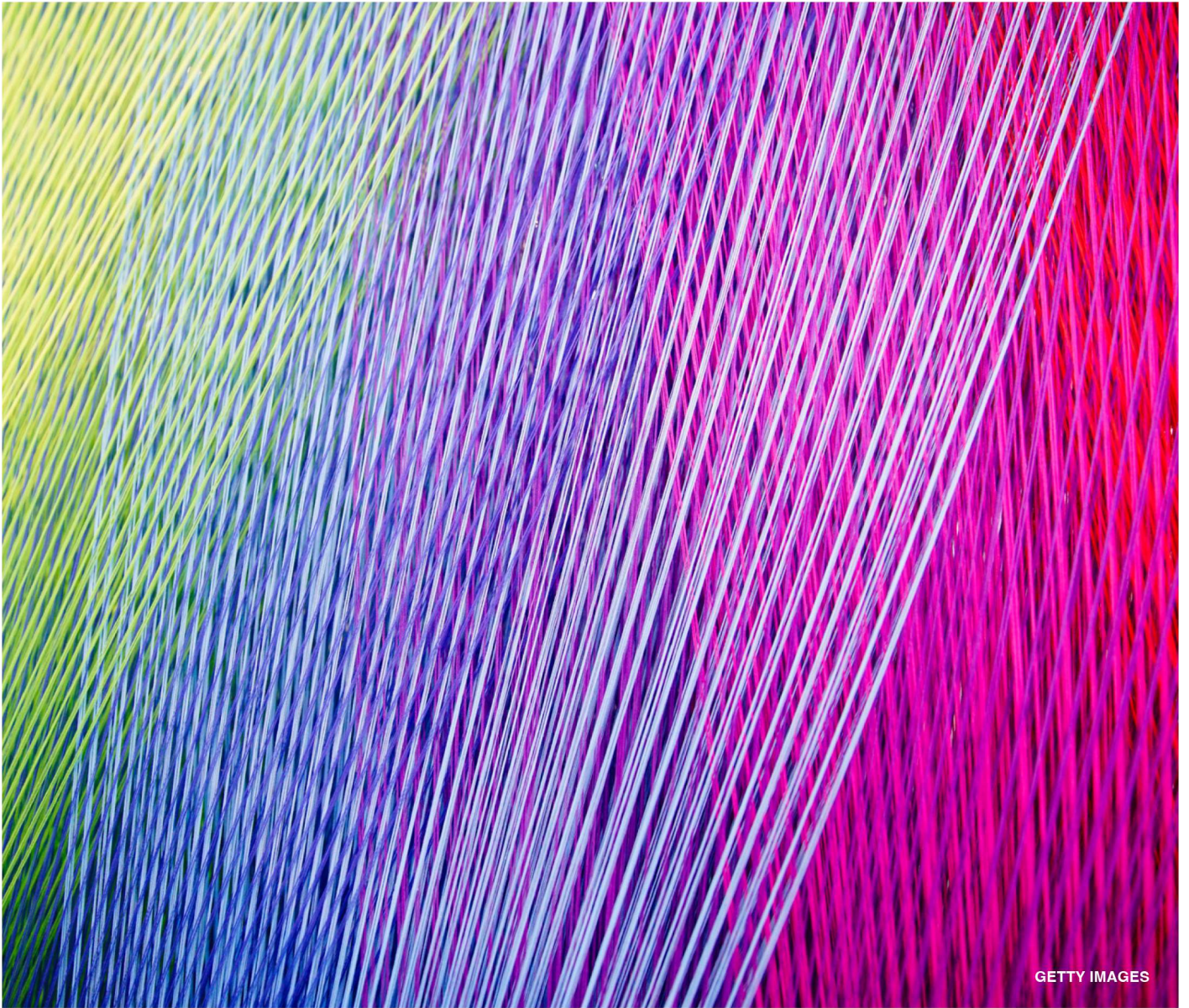
By providing advisory services

Brands can advance the industry by providing advisory services to next-gen material companies. These relationships help brands by giving them unique insight into the industry, and their advice helps material companies improve their products.

Because next-gen materials are relatively new and rapidly developing, sourcing them in the next few years may be different than what brands are used to. In Part 3, we lay out some sourcing challenges as well as recommendations for overcoming them. The MII team is happy to consult with brands looking to make this transition.

With so many new next-gen material options coming to market, fashion, home goods, and automotive brands and consumers will soon have more choices than animal-based **leather, wool, silk, down, fur, and exotic skins**.

Let's get ready for the next generation of materials!



PART I

Introduction

Overview

Despite significant challenges in the fashion industry over the past few years due to Covid-19, we are encouraged by the number of brands using next-gen materials in their products. The number of fashion, automotive, and home goods brands interested in next-gen materials has increased along with the supply of next-gen materials.¹ This market trend is not surprising given the increased consumer demand for animal-free and environmentally friendly products and the development of new technologies allowing for significant improvement in the aesthetics and performance of next-gen materials.

In this report, we explain three reasons brands are adding next-gen materials into their supply chains. First, and perhaps most importantly, is increased consumer demand for sustainable and animal-free products. Other reasons are the environmental benefit of next-gen materials over animal-based materials, including the continued animal cruelty when animals are used as commodities.

The majority of the report provides examples of products made from next-gen materials. Before now, there was no one source that listed how brands are working with next-gen materials and material companies. This trend is a clear indication that next-gen materials are part of a new industry and deserve attention as such. The beautiful images across a wide variety of products have inspired us, and we hope they inspire new brands, entrepreneurs, investors, and scientists to enter the next-gen materials industry.

This report also shows other ways brands can work with next-gen materials, including in-house development of next-gen materials, investment in next-gen material companies, and providing advisory services to next-gen material companies.

This report lays out some initial considerations for brands thinking about next-gen material partnerships and some specific advice on how to source in this nascent industry. If you are ready to explore the next-gen material industry, please reach out to us at info@materialinnovation.org.

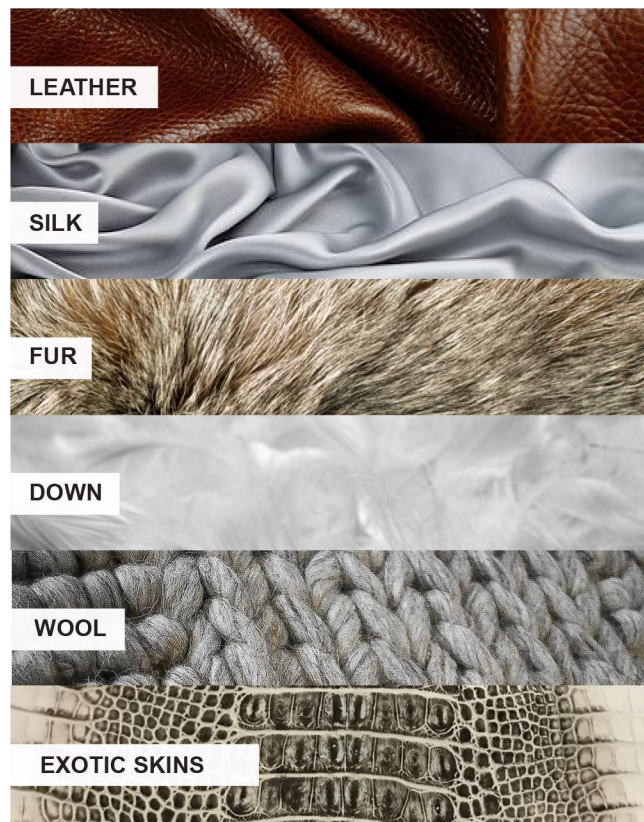


What are Next-Gen Materials?

“Next-gen materials” are livestock-free direct replacements for conventional animal-based leather, silk, wool, down, fur, and exotic skins (also referred to as **“incumbent materials”**). Next-gen materials use a variety of biomimicry approaches to replicate the aesthetics and performance of their animal-based counterparts.

Examples of exclusions from this definition:

- Materials that are not directly replacing animal-based materials;
- Materials designed for use in construction, thermal cooling, and packaging solutions that traditionally do not make use of animal-based materials;
- Recycling and upcycling technologies; Wearable technologies;
- Dye, cut, trim, or other manufacturing and supply chain technologies.



“Current-gen materials” are those used to substitute for animal-derived materials by winning on price. Synthesized leather made from petrochemicals, for example, sells at wholesale at one-third the price of the animal leather equivalent. We generalize these petroleum-based alternatives (e.g., polyurethane (PU), polyvinyl chloride (PVC), acrylic fiber) as “current-gen materials,” but their current applications in the market are far beyond animal-based material replacements. More clothing is made from polyester and nylon, both plastics, than from cotton. Examples of “current-gen” alternatives include PU for leather, polyester for silk, and acrylic for wool.

Animal-Based (“Incumbents”)

Humans have used leather, silk, wool, fur, down, and “exotic” skins for centuries. These animal-based materials present environmental and ethical challenges, which are increasingly urgent problems as the human population continues growing.

Synthetic (“Current-Gen”)

The invention of synthetics in the 20th century enabled inexpensive petroleum-derived alternatives to animal-based materials: polyurethane, PVC, polyester, acrylic and more. Unfortunately, these alternatives are also unsustainable and ethically fraught.

Next-Gen

A new crop of scientists, artists, and innovators are pioneering next-gen materials. These innovations are high performance, animal-free, and more sustainable. This is the next generation of our economy.

Some of the next-gen material companies market their material as next-gen, rather than as a next-gen replacement for a specific animal material. In this report, the material is placed in a next-gen category according to its use in the majority of brand products.

Main Input Categories

Not all next-gen materials are made using the same process or technology. We expect materials made from similar technologies to have similar advantages and disadvantages. To simplify the broad landscape of formulation and processing approaches for next-gen materials, MII categorizes next-gen innovation by main input (greater than 50%): plant-derived, mycelium, cultivated animal cells, microbe-derived, recycled material, and blend.

Please note that many material companies continually refine and update the formulations and technology behind their materials. At MII, we make every effort to keep up to date, especially on our [website](#). This report represents the best information available at the time of publication.

Plant-derived



Applies to next-gen materials derived from virgin or waste/byproduct plant matter. For simplicity, fungi (fruiting body), and algae inputs are included in this category, even though they are not plants.

Mycelium



Applies to next-gen materials that utilize the root-like structure of some fungal species called mycelium. This category is distinctive from the plant-derived category due to the rich activity of next-gen innovation involving mycelium.

Cultivated animal cells



Applies to next-gen materials that utilize tissue engineering approaches to grow animal cell constructs (e.g., skin) in the laboratory.

Microbe-derived



Applies to next-gen materials that utilize cellular engineering approaches such as cell culture or fermentation processes to produce products such as proteins and biopolymers for next-gen material formulations.

Recycled material



Applies to next-gen materials that utilize recycled plastic or recycled textile feedstock as a main input.

Blend



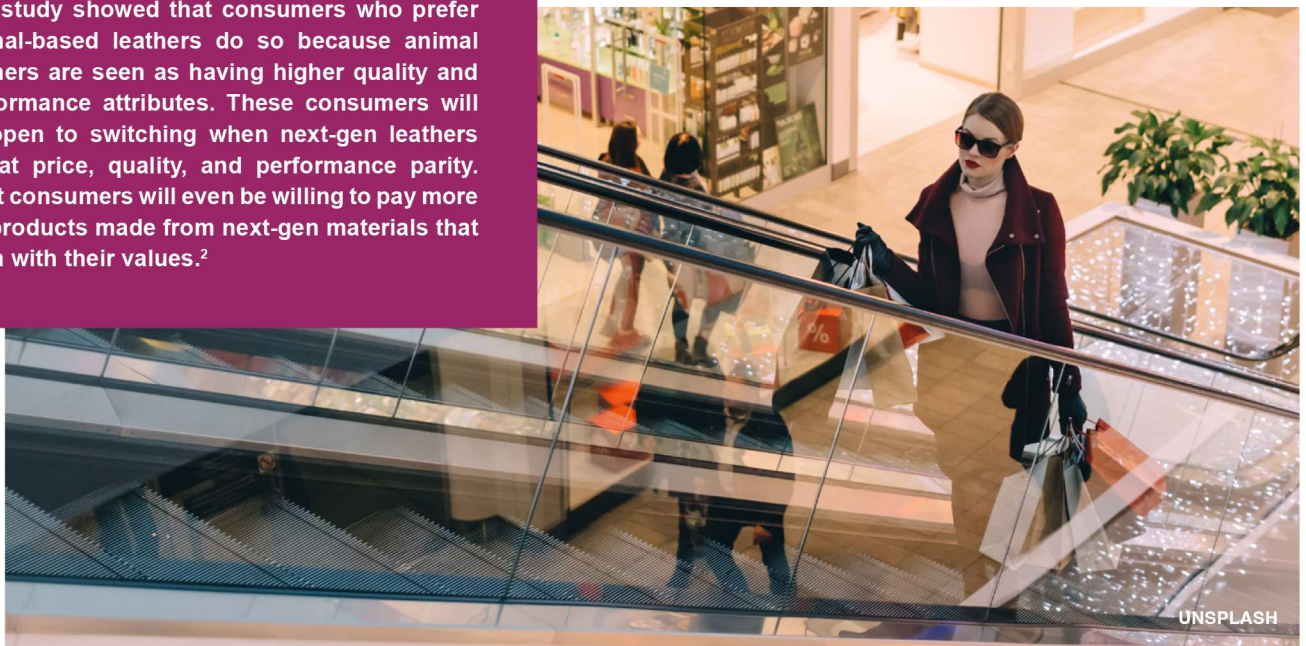
Applies to next-gen materials that use a blend of components not well-captured by any of the above categories.

Why Use Next-Gen Materials?

Why are so many top fashion, home goods, and automotive brands using next-gen materials? Quite simply, these brands expect to increase revenue by exemplifying their positive effect on the environment and animals. In this section, we highlight three reasons for brands to include next-gen materials in their product lines: 1) increased consumer demand for more sustainable and animal-free products, 2) next-gen materials' environmental impact, and 3) concerns about animal cruelty in industries where animals are commodities.

Consumer Demand

Our study showed that consumers who prefer animal-based leathers do so because animal leathers are seen as having higher quality and performance attributes. These consumers will be open to switching when next-gen leathers are at price, quality, and performance parity. Most consumers will even be willing to pay more for products made from next-gen materials that align with their values.²

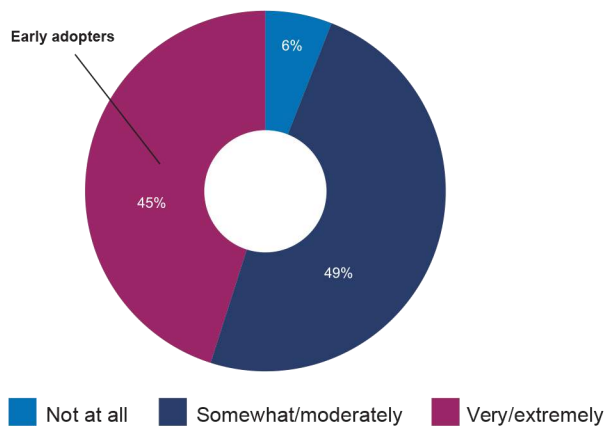


The incentives for brands to make money align with less environmental destruction and animal cruelty. Consumer research consistently shows that consumers in two of the largest markets for fashion, automotive, and home goods, the United States and China, want more sustainable and cruelty free products and are willing to pay more for them. Although consumers appreciate the quality of animal-based materials, their impact on the environment and on animal welfare continue to give rise to the desire for high quality alternatives more in line with consumers' values.³

Consumer Adoption of Next-Gen Materials: A U.S. Segmentation Study

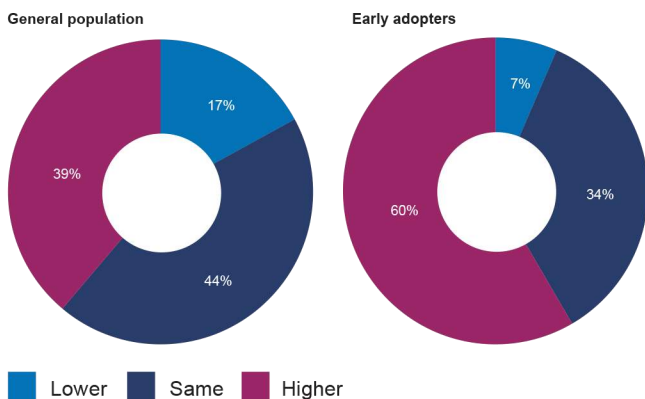
A study by MII and North Mountain Consulting Group released in September 2021 showed that in the United States, nearly all participants – 94% – stated they were at least somewhat likely to purchase next-gen materials, and nearly half – 45% – were highly likely to purchase.⁴ The respondents who reported a high level of purchase interest (*very* or *extremely likely* to purchase) are classified as “early adopters.”

Likelihood of purchasing next-gen materials



More than a third – 39% – of the general population said they would pay more next-gen materials and more than 60% of early adopters said they would pay more.⁵

Degree of importance of reasons to purchase next-gen materials



The main motivations for purchasing next-gen material was tied for early adopters with both animal-welfare and the environment tying at 81%. The general population is slightly more interested in next-gen materials for animal welfare reasons with animal welfare listed by 62% as the top motivator and the environment as the top motivator for 60%. Both early adopters and the general population also listed quality as an important factor.

Gen Z Attitudes Towards Environmental and Social Issues

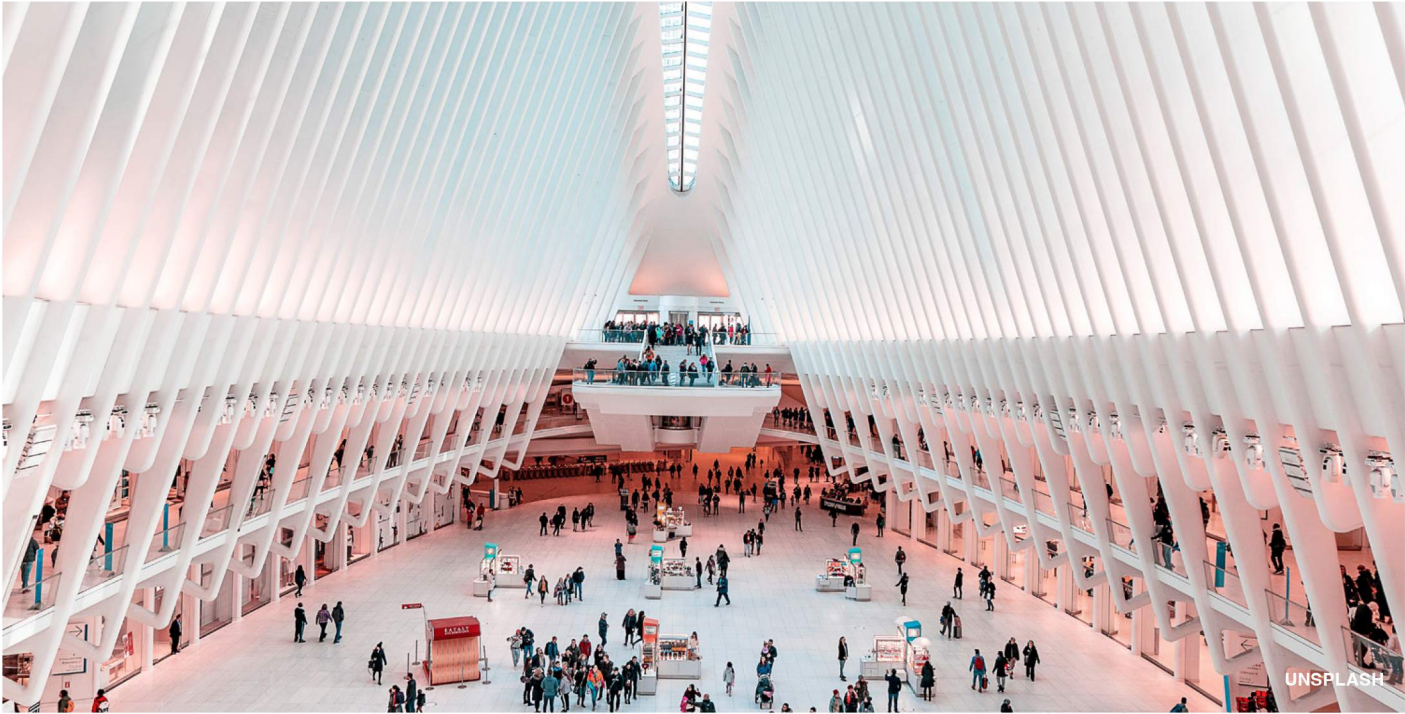
A 2019 Porter Novelli/Cone study on Gen Z surveyed U.S. youth aged 14-22, examining Gen-Z's expectations of and attitudes toward company involvement in social and environmental issues. The study found that 90% of Gen Z believe companies must drive action on social and environmental issues and are willing to hold those companies accountable. More than nine-in-10 (93 percent) say that companies should have appropriate programs and policies in place to back up all social and environmental commitments. Three-quarters of respondents will research whether companies are honest about their stand on issues. As the primary concern, the environment was listed first for 26% of respondents, ahead of poverty and hunger, human rights, economic development, health and disease, and education.⁶

Global Consumer Perception Survey on Sustainable Raw Materials in Fashion and Home Textiles

A 2000 Lenzing study surveyed 9,000 respondents aged 18 to 64 across nine countries and found:

- Almost all (86%) respondents believe purchasing clothes made from sustainable raw materials is a key component of living a more sustainable lifestyle. These respondents frequently purchase products from brands committed to using sustainable raw materials (80%) or recycled materials (77%).
- A majority of respondents research the production process of products before purchasing (76% in clothing and 74% in bedding and home textiles).
- A majority read label hangtags (88% in clothing and 86% in bedding and home textiles).
- Most respondents are willing to pay 40% more (on average) for clothing or home textile products with descriptions that reflect sustainability.

"When shopping for clothing and home textile products, respondents consider the material type to be their most important consideration (ranked in the top three factors for consideration by 44% of respondents), which is above price, design, brand reputation and function."⁷



Likelihood of purchasing next-gen materials

■ Not at all
 ■ Somewhat/moderately
 ■ Very/extremely

Environment



Animal welfare

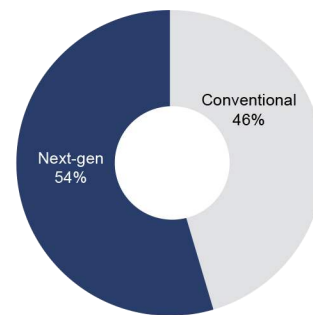


Quality

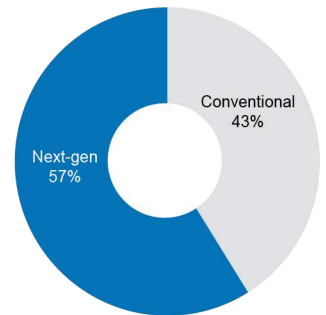


This analysis estimated that the market share for next-gen products would be over half of total purchases for each material subcategory: 54% of leather, 57% of wool, 60% of silk, 61% of down, 66% of fur, and 63% of exotic skins.⁸

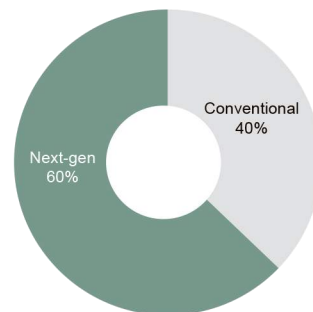
Potential market share: Leather



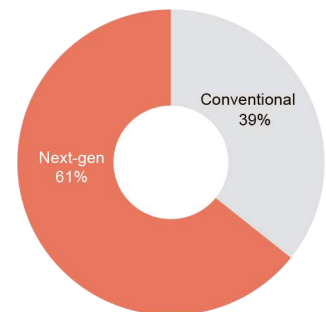
Potential market share: Wool



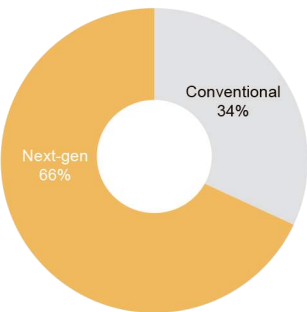
Potential market share: Silk



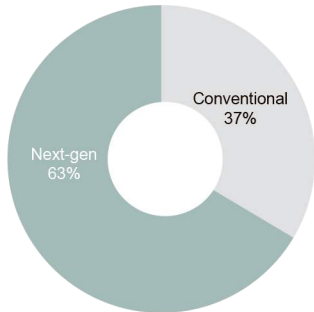
Potential market share: Down



Potential market share:
Fur



Potential market share:
Exotic skins



Next-Gen Leather:
Chinese Consumer Perceptions

In a 2021 survey of consumers in China, where the vast majority of animal leather is produced, the results were astounding: “The study showed the highest rates of acceptance toward a new technology I have yet seen - 90% of the participants selected a next-gen product over conventional and 70% reported a high likelihood of purchasing,” said Keri Szedja, Founder & Principal Research Scientist of NMCG.⁹ This study suggests there will be wide acceptance of next-gen leather in urban Chinese markets once at scale. With fashion industry revenue in China expected to be 383 billion USD in 2021, or 44% of the global total, the interest of Chinese consumers in next-gen materials is especially exciting.

Out of consumers who preferred next-gen leather (90%): The majority of participants (70%) were enthusiastic about purchasing and explained that they sought out alternatives because of concerns about the environment (72%), quality (72%), animal welfare (63%), personal expression (61%), and cost (56%).

Motivations for purchasing next-gen leather

■ Not at all ■ Somewhat/moderately ■ Very/extremely

Quality

Enthusiastic consumers



General population



Environment

Enthusiastic consumers



General population



Animal welfare

Enthusiastic consumers



General population



Personal expression

Enthusiastic consumers



General population



Cost

Enthusiastic consumers



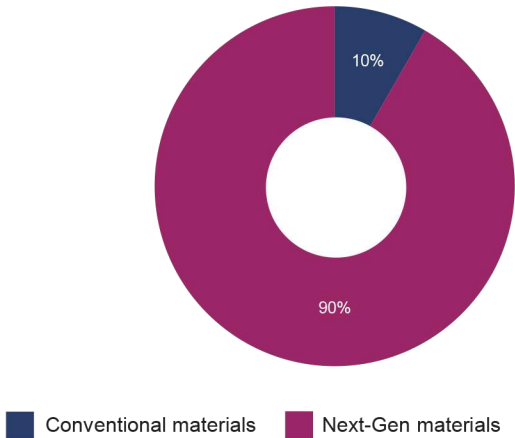
General population





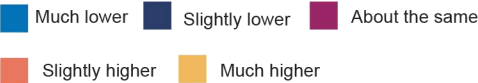
Material type preference by generation

General population



62% of the enthusiastic consumers indicated that they would pay a higher price. Millennials and members of Gen X expressed the greatest preference for and likelihood of purchasing next-gen leather (75-76% highly likely to purchase).

Amount likely to pay for next-gen leather



Enthusiastic consumers



General population



These results provide a first look at U.S. and Chinese consumers' preferences for alternative leathers and show a clear preference for next-gen leather over animal-based leather. As consumers who preferred animal-based leathers did so because they were perceived to have higher quality and performance attributes, we expect these consumers will be open to switching to next-gen leathers when they are at price, quality, and performance parity.

Environmental Impact

In a November 2021 study of fashion industry executives conducted by Business of Fashion and McKinsey, fashion industry executives listed the sustainability gap as the second most prominent challenge facing their companies in 2022, following supply chain disruptions. However, 12 percent of the executives surveyed also rated sustainability as an opportunity for 2022, suggesting that “any costs or challenges they encounter relating to sustainability may be outweighed by the business benefits associated with improving their company’s impact on the environment and society.”¹⁰

The largest environmental impact comes from raw materials

66 - 80%

of a brand's environmental footprint comes from its choice of raw materials

Although the percentage of impact will vary by brand and is usually not shared publicly, it is safe to assume that the largest source of a brand’s environmental impact comes from its choice of raw materials. Nike, one of the most transparent companies in sharing their environmental impact data, states that between 70-80% of their environmental impact comes from their choice of raw materials.¹¹ Nicole Rawling, MII’s CEO, has had confidential conversations with brands, all of which estimate the environmental impact of their raw materials to be between 75-80%. The Business of Fashion and McKinsey conclude that “Two thirds of the sustainability impact happens at the raw materials stage.”¹²

As shown you will see in this section, animal-based materials have a high environmental impact. A brand that uses a large amount of animal-based materials can reduce its impact significantly by making the switch to next-gen materials.

Animal-based material have a high environmental impact

Assessments consistently show that animal-derived materials are associated with high environmental impacts across a broad range of categories, including greenhouse gas (GHG) emissions, water use, and eutrophication. The process of breeding and raising animals for their skin, hair, or feathers requires tremendous amounts of resources and produces significant waste throughout the production process. For instance, it is estimated that more than 3,600 gallons of water are required to make just one pair of leather shoes, a number that pales in comparison to the water use of silk, often considered the “thirstiest” material.^{13,14} Research has shown that the cattle industry, which supplies the vast majority of the leather to the fashion, automotive, and home goods industries, is the “single largest driver of deforestation in the Amazon.”¹⁵ Leather and fur tanning processes often use hazardous chemicals such as arsenic, lead, formaldehyde, and chromium, which pose risks to worker health and runoffs can impact the local environment. Sheep raised for wool production and the cattle associated with leather production impact climate change due to their high methane production,¹⁶ which has 25 times the radiative force of an equal mass of carbon dioxide.¹⁷ The impacts of animal-derived materials are impossible to ignore.

We encourage brands to source from organizations like the Leather Working Group, but it is important to remember that any certification is only as good as its enforcement. A recent New York Times exposé reveals issues facing the certification industry. The extensive investigation connected Leather Working Group “gold” certified leather directly to Amazon deforestation.¹⁸ Cattle ranching is the largest cause of Amazon deforestation, accounting for over 80% of all deforestation.¹⁹ An additional report by Stand.earth, a supply chain research firm, and Slow Factory connected leather used by over 100 brands to Amazon deforestation.²⁰ Researchers also found that brand policies alone were not sufficient to end this destruction: “With a third of companies surveyed having some kind of policy in place, [you’d expect] that would have an impact on deforestation,” said Greg Higgs, one of the researchers involved in the report. “The rate of deforestation is increasing, so the policies have no material effect.”²¹ The Leather Working Group is working to improve its traceability protocols, but, according to them, “due the complexity of the farming systems in Brazil and lack of publicly available databases, there is still, unfortunately, no easy solution for this situation.”²²

"Increased policies, regulations, standards, and certifications, while good, are not enough. We need a new solution that gives both brands and consumers the high quality and reasonably priced products they need without the negative effects on the environment and animals. Next-gen materials are that solution."



Nicole Rawling
Chief Executive Officer
Material Innovation Initiative



Are the alternatives for animal-based materials better for the environment?

Sustainability is complicated, and incorrect information and greenwashing abound. We recognize that 1) not enough sustainability data exists for materials used in the fashion industry, 2) there are no consistent agreements on environmental impact analysis methodology, reporting, and comparison strategies among different materials, and 3) much of the data that currently exists is outdated, limited to one geography, and cannot necessarily be extrapolated to apply to all materials in that category.²³ Because the industry is in its nascent stage, and many companies are still conducting R&D, there is a dearth of environmental impact data for next-gen materials. In this section, we show examples of current environmental impact data on next-gen materials, provide overarching analysis, and suggest a starting point for continued analysis of environmental impact.

All data we have seen so far shows that next-gen materials, on the whole, are poised to have lower environmental impacts than animal-derived materials and current-gen alternatives.²⁴ In addition, many next-gen startups are focusing on responsible end-of-life strategies including biodegradation, reuse, and recycling.

The [Higg Index](#), the most widely used source of material environmental impact data in the fashion industry, enables evaluations of different raw materials through their Materials Sustainability Index (MSI) tool. Below, one can see the Higg-

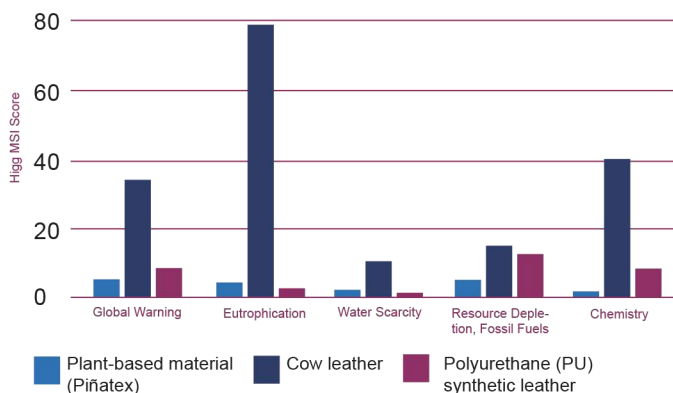
reported data for Piñatex® ("Plant-based material") compared with cow leather and PU synthetic leather. Piñatex® has lower environmental impact within all five impact factors compared with animal-based leather and beats out PU in GHG emissions, abiotic resource depletion, and chemistry.²⁵

The next-gen material company that produces Desserto®²⁶ has conducted early life cycle assessments on their cactus-based leather, demonstrating that their material has a lower environmental impact than both animal-based leather (ABL) and polyurethane leather (PU) across several impact factors. According to Desserto®, their next-gen leather saves:

- **878.26%** cumulative energy demand (MJ) compared to ABL and **78.96%** compared to PU.
- **1,864.02%** greenhouse gas emissions compared to ABL and **77.69%** compared to PU.
- **500%** eutrophication impact compared to ABL and **100%** compared to PU.
- **164,650%** of water compared to ABL and **190%** compared to PU.
- If incinerated, **1,416.66%** greenhouse gas emissions compared to ABL and **90.55%** compared to PU.
- **absorbs 8,100 tons of CO2** per year, and only generates **15.30 tons** of CO2 annually.

Similarly, Natural Fiber Welding reports that MIRUM®²⁷, their next-gen leather product, emits 40 times less carbon than bovine leather and 17 times less carbon than synthetic leather. NFW expects to share additional data from an LCA conducted on MIRUM® in early 2022.

Newlight Technologies' AirCarbon, a bio-based, biodegradable resin that has been used to make next-gen leather products, reports a *negative* carbon footprint: -87.76 kg CO₂e/kg as independently certified by Carbon Trust according to PAS 2050: 2011, demonstrating substantial impact reduction compared to animal-based leather or PU leather.²⁸



Data from Higg MSI Score

Orange Fiber, a next-gen silk, is a cellulosic fiber derived from orange juice waste, offering a 40% lower carbon footprint [kg CO₂ eq] compared to the average environmental profiles of current-gen cellulose production and preventing the cutting of virgin trees.²⁹



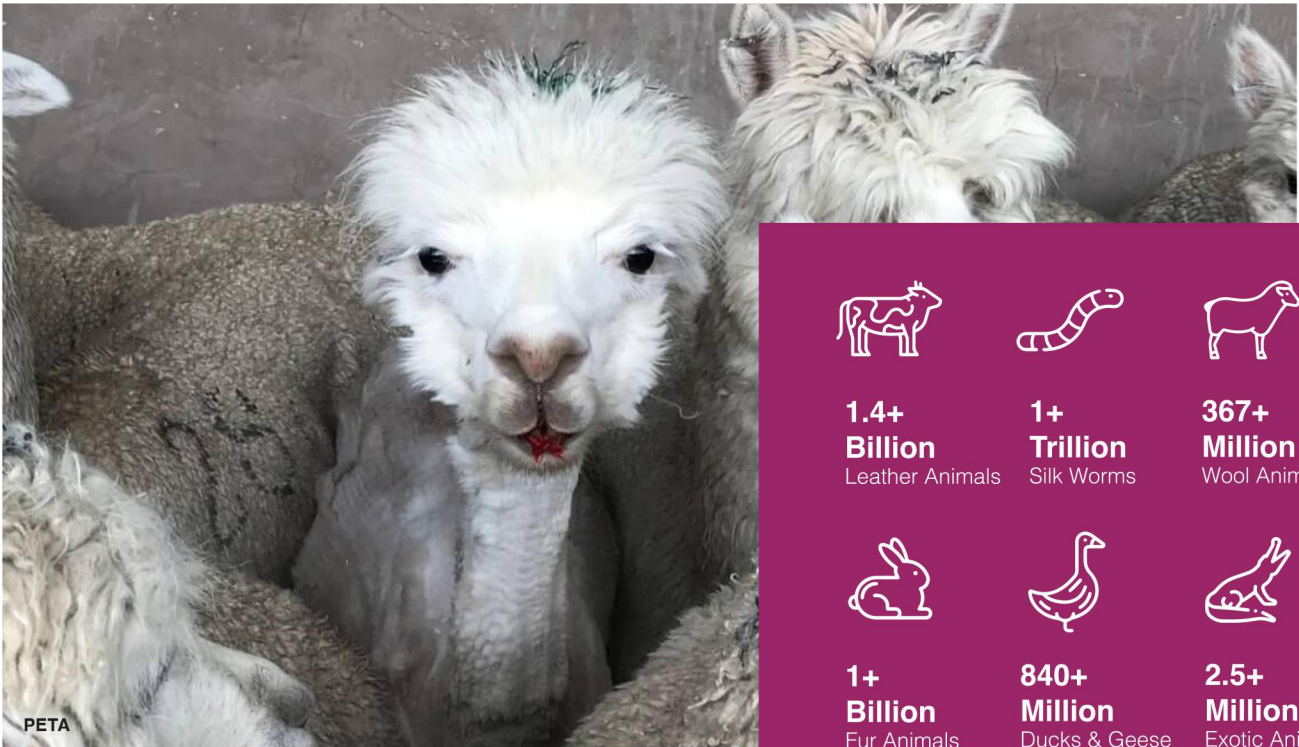
What about synthetics?

Synthetic materials are the primary input for the current-generation of replacements to animal-derived materials (e.g., PU for leather, polyester for silk, acrylic for wool). However, many of today's synthetic materials have undesirable environmental consequences, and thus are not the ideal solution for animal-free options. Although these current-gen materials are produced using fewer resources than animal-materials, current-gen materials are largely petroleum-based and non-biodegradable at the end of life. As such, they contribute to issues such as climate change and microplastic pollution,³⁰ both of which also cause animal suffering now and are predicted to cause even greater animal suffering in the future. Many fashion houses recognize this and have made it a priority to move away from virgin synthetics. To ensure a livable future and protect against the existential risks of climate change, pollution, and resource depletion, it is critical to move away from animal-derived materials and current-gen synthetics to next-gen materials.



Sydney Gladman, Ph.D.
Chief Scientific Officer
Material Innovation Initiative

Animal Welfare



**1.4+
Billion**
Leather Animals



**1+
Trillion**
Silk Worms



**367+
Million**
Wool Animals



**1+
Billion**
Fur Animals



**840+
Million**
Ducks & Geese



**2.5+
Million**
Exotic Animals

As shown in the consumer research section, even consumers who prefer animal-leather place a high value on animal welfare. We see this concern for animal welfare continuing especially as the market offers more choices that meet consumers' aesthetic and performance needs and are cruelty-free and more sustainable.

The concern for animal welfare has spurred new animal welfare certifications and bans on animal products. Despite these positive advancements, the fashion, automotive, and home goods industries continue to use billions of animals and trillions of silkworms every year for their skin, hair, fur, feathers, and silk. Undercover investigations continue to show violations of certification requirements including animal cruelty and environmental destruction. Although the industry is moving towards higher animal welfare standards, when animals are treated as a commodity in industries notorious for low profit margins, their space, comfort, bodily integrity, social interactions, and emotional needs will be sacrificed for profit.

Movement towards better animal welfare

Industry trade associations and independent nonprofits continue to implement animal-welfare standards to comply with increased consumer concerns over the treatment of animals. Examples include the International Wool Textile Organisation (IWTO) Guidelines for Wool Sheep Welfare;³¹ Textile Exchange's Responsible Leather, Wool, Down, Mohair, and Alpaca Standards;³² and Kering's Animal Welfare Standards.³³

Brands are increasingly banning the use of certain materials. Burberry, Gucci, and Prada banned the use of fur. Chanel, Diane von Furstenberg, and Mulberry banned many exotic skins, and PVH, which owns Calvin Klein and Tommy Hilfiger, banned angora, fur, and exotic skins.³⁴ Some luxury brands such as LVMH³⁵ and Hermès³⁶ have expressed their concern for animal welfare by building new production facilities and bringing the production of exotic skins under their control.

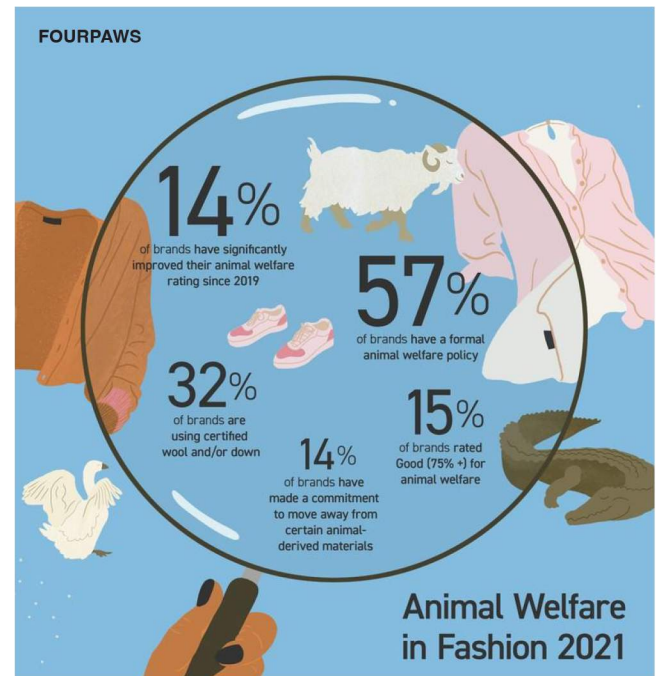
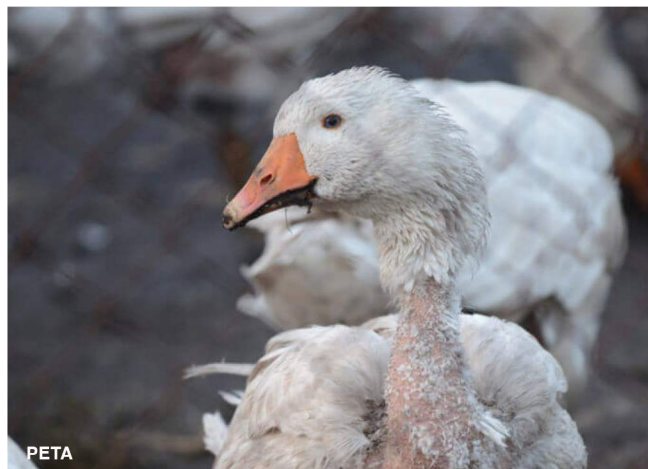
Fashion media is joining this trend as well: ELLE magazine has banned the inclusion of fur in all of its international titles due to animal welfare concerns.³⁷

Fashion shows all over the world are joining brands in banning certain animal materials from the runway. Stockholm's Fashion Week banned fur and exotic skins in fall 2020, London Fashion Week banned fur in 2018, and the Melbourne and Helsinki fashion weeks banned exotic skins in 2018.³⁸

In addition, many countries are implementing more stringent animal-welfare regulations or outright banning the production or sale of some animal-based materials. For example, over the past two decades, twenty countries have voted to ban fur production, to prohibit the farming of particular species, or to implement stricter regulations.³⁹

Why these steps aren't enough

Although these are important steps towards a less cruel industry, they are not sufficient. In the second edition of The Animal Welfare in Fashion Report, published in December 2021, Four Paws International and Good On You used detailed methodology to assess 111 brands from fourteen countries on their progress in animal welfare. Although more brands addressed animal welfare in 2021 than in 2019, "there is a long way to go before the fashion industry can be considered as achieving even a basic level of animal welfare."⁴⁰ Even though the demand for animal-free fashion is rapidly growing, as seen above in Consumer Research, only 57% of brands have an animal welfare policy at all. Just 32% of brands source certified wool or down and a mere 14% significantly improved their animal welfare rating since 2019.



As shown above in the Environmental Impact section, certifications are only as good as enforcement. Investigations recently tied "gold" standard leather by the Leather Working Group to Amazon deforestation and another investigation linked specific brands directly to the same deforestation. In addition, we routinely see violations of animal welfare standards exposed in undercover investigations.⁴¹ A recent undercover investigation in two Finnish fur farms found multiple animal-welfare violations despite the farms having "the highest level of animal welfare," according to the fur trade's SAGA Furs certification program.⁴²

Industries with low profit margins, such as animal agriculture, face significant pressure to cut costs. Companies that use animals will consistently choose profit over the well-being of animals. Well-being is routinely sacrificed because it is seen as too expensive to give animals more room, a natural habitat, or the ability to interact with their own species. The animal-based material supply chain is complicated and even certifying bodies cannot guarantee their own certifications. For example, in their response to the investigation linking their certified leather and Amazon deforestation, the Leather Working Group cited the complexity of the leather supply chain and said there was "unfortunately, no easy solution,"⁴³ giving little hope that certifications alone can solve these problems. This means billions of animals suffer every year, and this will not stop until we move away from using them as commodities.



PART II

Working With Next-Gen Materials

A. Via Partnership

Overview

One way for brands to begin working with next-gen materials is via partnerships with next-gen material innovators and suppliers. Partnerships between brands and next-gen material companies come in all shapes and sizes. Some partnerships are exclusive; other material companies sell to all. Some material suppliers only produce one next-gen material, some companies produce a few. Some large material companies have a wide range of offerings, but only one or two next-gen materials. Brands seek partnerships with next-gen material companies for capsule collections as well as for staple and non-seasonal items.

In this section, we provide a selection of partnerships between brands and next-gen material companies. This is by no means an exhaustive list, as new partnerships are being formed on an almost daily basis in this rapidly moving new space. We showcase a sufficient variety of examples for readers to use for reference and inspiration.

Partnerships are listed by next-gen material: leather, down, silk, wool, and fur, respectively.

“Brands may want to test the next-gen waters by sampling with several next-gen innovators to find what matches their brand aesthetic. By sampling, the brand can evaluate not only the material, but also how the innovator responds to brand needs including timing.

Another option for brands is to do extensive research and go all-in with one next-gen material company. Co-branding is yet another opportunity for working with next-gen material companies.

In terms of both financial risk and customer perception, the safe way for many larger brands to explore next-gen material use is to offer capsule collections. After investing time and resources in sampling various materials, choosing the best fit, and creating a product, the brand can promote their next-gen product in a capsule collection. Launching via a capsule collection enables a brand to observe consumer reaction and desire with reduced financial or reputational risk.”



Thomasine Dolan
Fashion Design Specialist
Material Innovation Initiative



VON HOLZHAUSEN



Next-Gen Leather

Introduction

According to Lyst, a premium fashion shopping app with over 150 million annual users, searches for “vegan leather” have increased by 69% year-on-year, averaging 33,100 online monthly searches in 2020, while searches for “faux leather” have remained constant.⁴⁴ This data suggests that customers are responding more positively to the word “vegan” rather than “faux.” Searches for “eco vegan leather” have also increased, showing that shoppers are becoming aware of the fact that not all vegan options are environmentally friendly. At the same time, searches for “leather” have decreased by 3.5% year-on-year.⁴⁵

This section covers many partnerships between brands and next-gen material innovation companies, and next-gen leather* derived from plants, microbes, mycelium, or a blend of bio- and synthetic materials.

**Some companies market their material as next-gen, rather than as a next-gen replacement for a specific animal material. In this report, the material is placed in a next-gen category according to its use in the majority of brand products.*



Ananas Anam, better known by its trademarked non-woven fabric Piñatex®, has developed one of the more widely available next-gen materials currently in the market and produced at scale. Piñatex® is made of fiber from the waste leaves of the pineapple plant. Pineapple leaf fiber is processed in the Philippines to create Piñafelt, a non-woven mesh which forms the base of all Piñatex collections, before being shipped to Spain or Italy for specialised finishing. Ananas Anam currently offers multiple collections created by coloring the Piñafelt using Global Organic Textile Standard (GOTS) certified pigments and a REACH⁴⁶ compliant PU resin top coating which may be bio-based, water-based, and/or high solid PU depending upon the formulation. Piñatex® can be used for applications in clothings, accessories, and upholstery, and **Ananas Anam** has partnered with over 1000 brands worldwide.



ANANAS ANAM



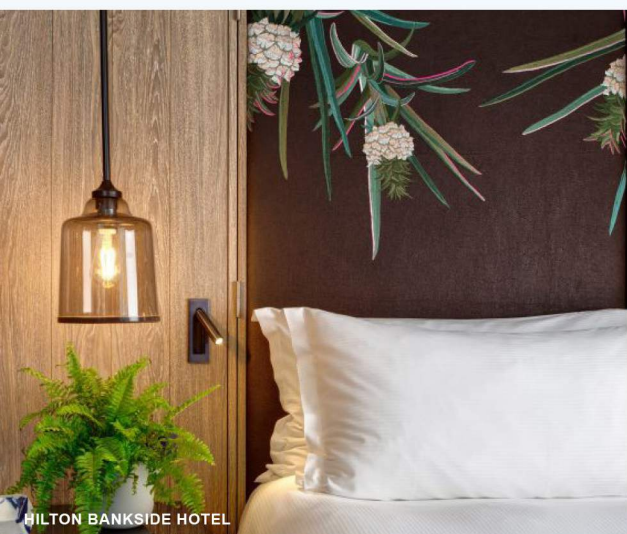
NIKE

Nike teamed up with Ananas Anam to launch a new plant-based sneaker collection in 2021. The colorful Happy Pineapple line included five Nike sneaker models made of Piñatex®. The material is used on some of **Nike's** most iconic models in several colors, including Air Force 1 and Air Max 90.

SELFRIDGES & CO

MĀRĪCĪ

Māricī, a slow-fashion brand from London that produces artisan vegan bags in Italy, chose Piñatex® because it meets the brand's standards of quality and aesthetics and also because of its low environmental impact and high social responsibility. Māricī exclusively launched in the British department store **Selfridges** in July 2021.

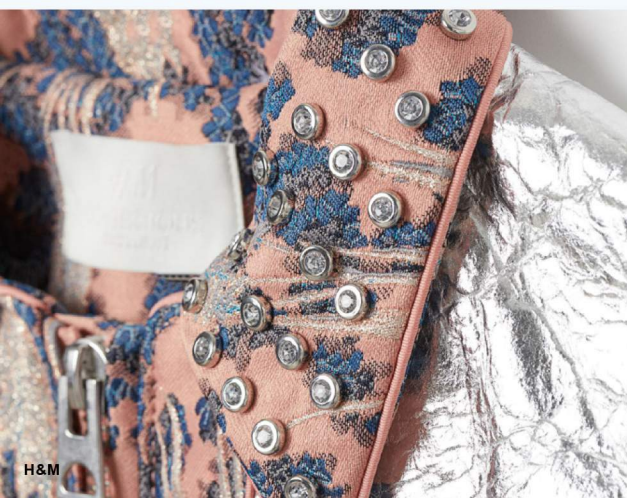



Hilton
 LONDON TOWER BRIDGE

In 2019, the **Hilton** Bankside Hotel commissioned design studio Bompas & Parr to create the world's first vegan suite to show that veganism is not only a dining trend but can also influence a wider lifestyle choice. For this project, most surfaces were upholstered in Piñatex®, such as the room's slate grey seating covers, bright red cushions, and a flower-embroidered headboard.

BOSS
HUGO BOSS

Hugo Boss launched a new Boss Menswear shoe produced with Piñatex® in 2018. The project is part of the brand's continuous search for innovative sustainable ways to design, source, and produce. The shoe design also included natural plant-based dyes and recycled TPU soles, making the product 100% vegan. The Boss shoes were made in four colors and sold in selected Boss retail stores worldwide as well as in the online store.



H&M

H&M's Conscious Exclusive Collection in 2019 featured a number of next-gen materials, including Piñatex®, used as silver details in jackets and boots. The products were available in approximately 100 stores worldwide.



DESSERTO

Established in 2019, **Adriano Di Marti** (more widely known as Desserto®, their trademark “cactus leather”) started their liaison with the maisons early. The company is part of LVMH’s accelerator program La Maison des Startups LVMH to gain exposure and develop business opportunities with the 75 maisons of the LVMH group. The company’s next-gen leather is made with nopal cactus, a plant natively found in Mexico. Desserto® is currently available in a number of lines and in a variety of colors, textures, and backings (including cotton, virgin/recycled polyester, and polycotton mix). The company will work with brands to develop customized materials with different aesthetics and technical specifications. In 2021, Adriano Di Marti announced Deserttex®, an exclusive material developed for automotive applications (see section [Special: The Automotive Industry](#)).



KARL X AMBER VALLETTA KARL LAGERFELD

Karl Lagerfeld collaborated with model, actress, and activist Amber Valletta to co-create a sustainable accessories collection for Spring 2021. A cornerstone of the collaboration is the K/ Kushion bag, a squishy style introduced as part of Karl Lagerfeld’s fall 2020 collection. The bag’s ribbed texture and pillow-like proportions were inspired by a special cushion Lagerfeld always traveled with. One version, available in green or black, is made of Desserto®.

Valletta lauded the brand for allowing her to delve into all aspects of their supply chain to minimize the carbon footprint of all Karl Lagerfeld x Amber Valletta products. In an interview with WWD,⁴⁷ Valletta said that the brand was great about letting her ask deeper questions about the factories, how they operate, their certifications and things like that; that it was very open, conscientious and took the time to answer difficult questions.

K/KUSHION BAG IN BLACK AS SEEN ON INSTAGRAM:





In 2021, **adidas** announced the launch of the Tilt 350™ boxing gloves, with a new design and new material made from sustainable nopal cactus leather. With these boxing gloves, **adidas** “wants to leave a big footprint in the ring, but a small footprint on Earth” and looks forward to expanding the partnership with Desserto® to manufacture other products.



DESSERTO



ADIDAS



FOSSIL

FOSSIL

Luxury watch and fashion accessory brand **Fossil** launched a collection of bags created with Desserto® to celebrate Earth Month in 2021. The project is part of the ‘Make Time For Good’ initiative launched in 2019 dedicated to having a positive impact on the environment through pro-planet materials, products, and packaging, and by reducing water use and carbon emissions.



H&M introduced its new sustainable concept, Innovation Stories, in a range of collections launched throughout 2021. It debuted with the collection **Science Story** that includes pieces developed using Desserto®, available in selected stores and at hm.com.

According to Ella Soccorsi, Concept Designer at H&M, Innovation Stories is a platform that encourages the brand’s work with scientists and developers. The Science Story collection is a homage to the years of research and experiments behind the incredible next-gen materials.



FROM THE SCIENCE STORY COLLECTION. H&M

SANABUL



The world’s first boxing gloves made using Desserto® were launched in 2020 by Sanabul, a U.S. martial arts and athletic equipment brand. **Sanabul** has made boxing gloves and other sports equipment from synthetic leather instead of animal-based materials since their founding. With the Los Cactus gloves, the brand has taken the commitment to reduce the environmental footprint of their products a step further.

Sanabul stated that, “with enhanced durability, optimal feel, improved sustainability and reduced environmental impact, cactus leather is the material of the future, leaving animal and most synthetic materials in the past.”



Founded in 2015, **Natural Fiber Welding, Inc. (NFW®)** is a material science company giving industries categorically new material platforms to create responsibly. **MIRUM®** is a plant-based, plastic-free material with customizability that means it can look and feel like leather, or carbon fiber. At the end of its life, **MIRUM®** can be recycled into new **MIRUM®** or ground up and safely returned to the earth. NFW®'s patented process allows for a range of independently definable characteristics such as thickness, flexibility, texture, color, pattern, and finish.



WOOLLY MADE. PHOTO BY BRETT RHOADES.

PDX, OR WOOLLY USA

According to **Woolly Made**, the advantages of **MIRUM®** over premium bovine leather include:

- **stretch and recovery**

MIRUM® can return to its original snug fit after stretching.

- **visibility of wear**

MIRUM® only develops minor patina.

- **easy material care/treatment**

MIRUM® is water resistant such that dirt and stains can simply be wiped clean, whereas leather absorbs fluids and requires treatment with conditioning oil every 3-6 months.

The Portland-based wallets and accessories maker **Woolly Made** launched their new “plant wallets” line using **MIRUM®** to create a plastic-free leather alternative in their collection.

Together, they piloted a circular buy-back program that will accept returned used products from customers to feed the plant-based material back into the earth as nutrients, helping to produce more renewable resources and close the circularity loop.



MODHER

MODHER MADE IN ITALY

The luxury leather bag brand **MODHER** launched a vegan Maya crossbody bag made with **MIRUM®**. The bag will be made to order and handcrafted in Tuscany, Italy.

Using the next-gen leather is a first for the brand, which has the proud tradition of using animal leather exclusively produced in Italy. The brand's founder Gianna Caravello is dedicated to “designing a completely plastic-free and natural experience.”



A collaboration between Woolly Made and NFW



In 2020, the Australian accessories brand **Bellroy** partnered with NFW to produce MIRUM® coconut leather patches for their plant-based pouches. The production starts with coconut husk fiber, a by-product of producing coconut water and coconut oil. No additional water inputs nor any petrochemical adhesives are required. Bellroy is extending their partnership with NFW® to create several small carry accessories made with MIRUM®, including the hands-free sling shown here, and others that will launch in 2022.



Sustainable fashion brand **PANGAIA** created a biobased leather collection with MIRUM® using a GOTS-certified cotton fabric backer.



Ralph Lauren designed the Team USA Closing Ceremony Parade Uniforms and apparel collection for the 2020 U.S. Olympic and Paralympic Teams. The collection used entirely sustainable materials, debuting technologies Ralph Lauren invested in, including patches made with MIRUM®.

Coming Soon

Many more brands, designers, and makers announced their partnerships with NFW® in 2021 to create products made with MIRUM®, including **Richemont**, **Alexander McQueen**, and **Allbirds**.



NFW® and luxury group **Richemont** announced a collaboration to incorporate MIRUM® as a sustainable, next-gen material into **Richemont's** products.

Through their collaboration with Richemont, NFW® continues to demonstrate the attractiveness of their materials to even the most discerning clients, as well as their dedication to scaling their plastic-free, plant-based leather technology.



London designer **Alexander McQueen** partnered with NFW®, to create a capsule collection of men's jackets made with MIRUM®. This limited collection will include 12 jackets, each featuring one-of-a-kind artwork hand painted by artist **Kevin Emerson**.



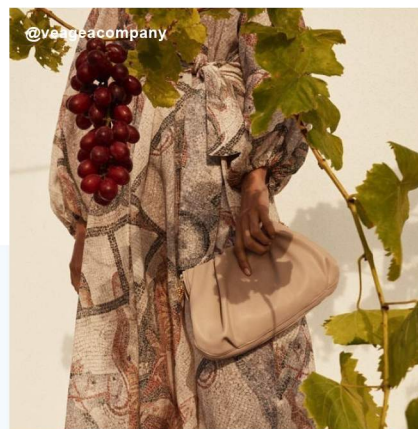
New Zealand-born, eco-friendly shoe brand **Allbirds** invested in NFW® in 2021 to support the scalable production of MIRUM®. MIRUM® supports the companies' shared goal of eradicating petroleum from the fashion industry.



VEGEA, founded in Milan in 2016, is known for their “grape leather.” The company discovered that grape marc, the remains after pressing the grapes into wine, contains fibers and oils ideal for the development of a more sustainable material that resembles the mechanical, aesthetic, and sensory characteristics of bovine skin. In collaboration with Italian wineries, VEGEA patented a process for the production of grape leather made from wine residues, without using any toxic solvents, heavy metals, or harmful substances. The company continues to research using other agricultural waste to create plant-based materials.



H&M has used VEGEA in multiple collections since 2020, including VEGEA special edition crocodile pattern for H&M's Co-Exist Story Collection shown here that is 100% vegan and 100% PETA-approved. The collection is a celebration of the harmonious coexistence of humans and other animals on this planet. H&M has made public their goal of using only recycled or sustainably sourced materials by 2030.



Shoes and bags made with VEGEA forming the Conscious Exclusive Collection 2020.

Credit of all images to VEGEA. Source: Instagram @veageacompany.



The French sports equipment brand **Le Coq Sportif** has presented several vegan sneakers made with **VEGEA**. The next-gen leather was used to design a classic model and retro runner, which also featured cork insole and a rubber outsole.



GANNI

Dedicated to eliminating animal-based leather within the next few years, Danish contemporary brand **Ganni** unveiled a new footwear collection made with **VEGEA**. The eight styles of footwear, including chunky loafers, slides, and flip flops, were made with 55% grape waste and 45% water-based polyurethane.



SERAPIAN MILANO

The traditional Milanese brand **Serapien** partnered with **VEGEA** to launch their first sustainable collection. Serapien has always been known for using noble leathers and materials and also for its refined tonal palette and soft geometric shapes.

In 2017, Serapien became part of the luxurious **Richemont Group**.



PANGAIA

PANGAIA launched the "grape leather sneaker" in 2021 in black and white. The brand describes the sneaker as ultra-comfortable, lightweight and breathable. The material requires minimal water and vegetable tanning alternatives. It also allows for a Strobel shoe construction that is used in most athletic shoes. The Strobel construction requires the upper material to be sewn to a fabric bottom creating a 'sock'. The upper and bottom are joined by a strobel stitch, using a strobel machine. With the upper sock tightly lasted, the upper is cemented to the outsole completing the shoe.

Other sustainable fashion brands including **Redemption**, **Maison Peaux Neuves**, **Roman Raibaudi** and **& Other Stories** have also chosen **VEGEA** for the production of their bags, accessories, and shoes.



Also derived from fruit residues, **Frumat** developed the technology to turn apple waste into their next-gen leather AppleSkin™. The material is manufactured by **Mabel**, contains a minimum of 50% apple fiber, and is created in Bolzano, Italy using Frumat's patented process. "PelleMela" (apple skin in Italian) is designed at the production site and is available in a variety of thicknesses and textures.



MIOMOJO



Sustainable Italian fashion brand **Miomojo** uses AppleSkin™ in multiple product lines. The brand also offers products made from other sustainable materials such as bamboo, hemp, cactus leather, and recycled plastic waste.



GUS* DESIGN GROUP



Toronto-based furniture design and manufacturing company **Gus* Design Group** launched an AppleSkin™ collection in 2021. Upholstered chair, sofa, and ottoman are available in AppleSkin™ in two custom colors: cognac and licorice.



MIOMOJO



MIOMOJO



GUS* DESIGN GROUP

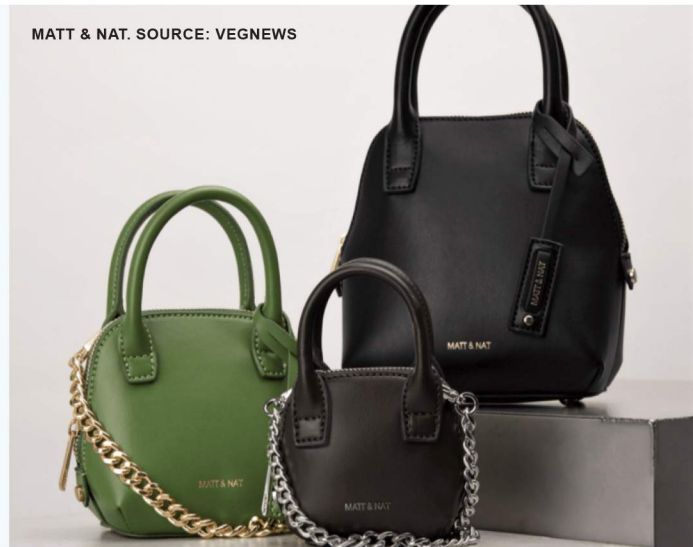


GUS* DESIGN GROUP

MATT & NAT

Matt & Nat partnered with Frumat to create their Studio 901 collection of 12 handbags made with AppleSkin™. Interior linings of all Matt & Nat products are made from 100% recycled water bottles.

MATT & NAT. SOURCE: VEGNEWS



Frumat has partnered with many other brands and designers to produce bags, shoes, and accessories, including: **Allégorie**, **Veerah**, **Samara**, **Womsh**, **Luxtra London**, **Komrads**, **Good Guys Don't Wear Leather**, **Skagen**, **Sylvén New York**, and **Mochni**, among others.



LUXTRA LONDON



ALLÉGORIE



GOOD GUYS DON'T WEAR LEATHER



SYLVÉN NEW YORK

FRUITLEATHER ROTTERDAM

Fruitleather Rotterdam creates next-gen material made from peels and other fruit waste, ideal as a leather alternative for shoe and accessory applications. The invention also bore fruit in partnerships with many brands, including **Luxtra London**, **iamoo**, **Windmillkey**, and **Saye**.



FRUITLEATHER ROTTERDAM



HEMP BLACK

The traditional Australian luxury fashion brand **Oroton** partnered with the next-gen leather company **Hemp Black** to create a range of unisex bags. The animal-free material used on the straps, handles, and inner linings features odor-neutralizing properties. This eco-conscious alternative to leather requires 90% less water and energy than the production of conventional synthetic leather.



OROTON

NOVA MILAN

Nova Milan creates plant-based leather from pineapple leaves, coconuts, hemp, and bananas. They have successfully printed on their vegan leather utilizing Kornit technology.

The Kornit printed plant-based leather debuted with its partnership with **NAOT** at Kornit Fashion Week. The company said they have other luxury brand partnerships to be announced.



NOVA MILAN

ZVNDER

Zvnder is carved from *Fomes fomentarius*, also known as tinder fungus, to create a next-gen leather material. **COILEX** used Zvnder fungus leather to create the nat-2™ vegan sneaker line. The sneakers are made by hand in Italy from tinder fungus, microfiber suede from recycled PET bottles, cork insoles, and rubber outsoles.



COILEX



Scientists at **Bolt Threads** reproduced in the lab what happens under the forest floor, where mycelium grows best. In 2018, Bolt Threads launched their innovative Mylo™ material. Mylo™ is a mycelium-based leather alternative. To make Mylo™, scientists reproduce what happens on the forest floor in a lab by feeding mycelial cells sawdust and other organic material. According to the company, it has since built a world-class supply chain to “deliver millions of square feet of Mylo™” while minimizing its environmental impact. Its European tanning partner has five generations of experience working with leather and meets top certifications in sustainability. Bolt Threads’ mycelium partner operates in the Netherlands and utilizes vertical farming to minimize their ecological footprint. Most of the partnerships shown here are concept designs. The first Mylo™ material products will be available starting 2022 through its consortium with **adidas**, **Kering**, **lululemon**, and **Stella McCartney**. Product availability and timing will vary by designer.

STELLA MCCARTNEY

THE THREE “FIRSTS” WITH STELLA MCCARTNEY



2018: Falabella bag made with Mylo™

The luxury house has been part of the Mylo™ journey since its inception.

The first product created with Mylo™ was a prototype of Stella’s iconic Falabella bag, which debuted as part of the Victoria & Albert Museum’s *Fashioned from Nature* exhibition in 2018. The brand first introduced the iconic vegan luxury ‘it bag’ Falabella tote in 2009 and has sold over 1 million since then, equivalent to the skin of approximately 400,000 cows.⁴⁸

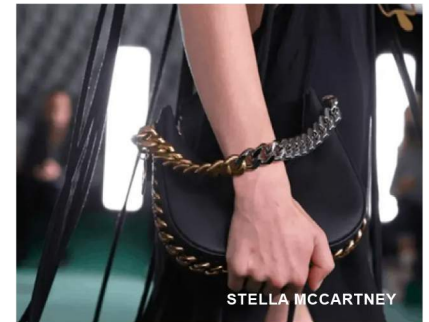


2021: Paris Jackson in Mylo™ bustier (Image source: Green Queen)

In Spring 2021, **Stella McCartney** unveiled the industry’s first-ever Mylo™ garments: a jet-black bustier and utility pants.

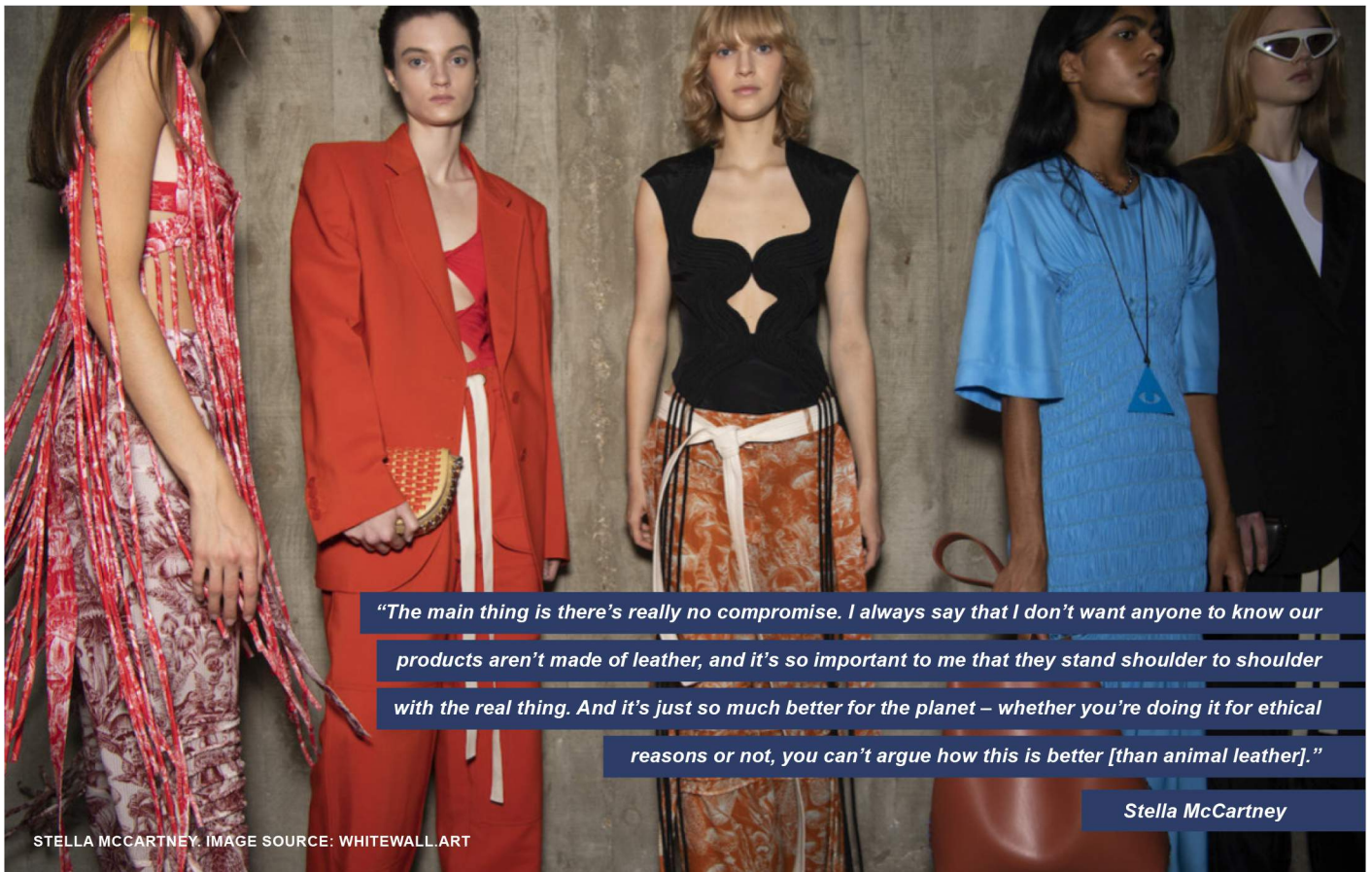
“We’d already done a bag, so I wanted to do the ready-to-wear to give a bit more insight into how much you can do with this material, and how it can be swept across the industry to actually replace leather,” McCartney explained. “That’s obviously the ultimate goal.”

Previously it had not been possible to create pieces of Mylo™ that were large enough to cut into pants, and the early iterations were “quite stiff,” as McCartney puts it. Now, Mylo™ is available in a range of weights and textures, from pebbled to ultra-soft and pliable.⁴⁹



2021-2022: The Frayme Mylo™ Bag at Paris Fashion Week 2021

The Frayme Mylo™ Bag by **Stella McCartney** at Paris Fashion Week 2021. Mylo™ made its debut on the runway at Paris Fashion Week as part of Stella McCartney’s Summer 2022 collection. Launching the Frayme bag made from Mylo™, the designer herself considers this a “landmark moment” for mycelium leather. The Frayme bag is a new Stella icon, inspired by the iconic Falabella tote and including an oversized recyclable aluminium chain strap that runs around the bag as well as a zamac statement medallion. The Frayme Mylo™ will be sold in a limited edition in 2022.



Stella McCartney's SS22 collection is inspired by mushrooms, and a declaration that mushrooms are the future of fashion. Sixty-three per cent of the collection is made from eco-friendly materials.

Exclusive Access*

In 2020, Bolt Threads created a consortium with **adidas**, **Kering**, **lululemon**, and **Stella McCartney** for exclusive access to Mylo™. This consortium is the largest joint development agreement in consumer biomaterials to date. Mylo™ is drawing attention from luxury and consumer brands because of its resemblance to soft, supple leather, and the fact that it can be made in any color, finish, or embossing. Some of the products from this consortium include:



In 2021, **adidas** launched new Stan Smith sneakers, the body of which is made from Mylo™. This partnership helps adidas meet their broader sustainability goals by using a naturally derived alternative to non-biodegradable plastic polymers.



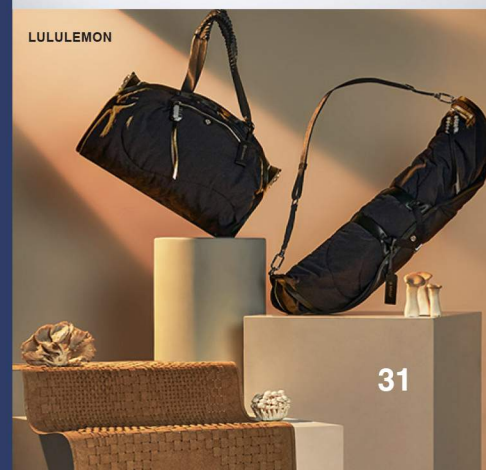
The yoga gear collection from Canadian premium athletic retailer **lululemon** will be available in 2022. Made with Mylo™, this collection features a woven yoga mat, a yoga bag, and a duffel bag.

*Danish brand **Ganni** has announced that its two wallets and a bag made with Mylo™ will be available in 2022.

ADIDAS



LULULEMON





Artist and inventor Philip Ross began using mycelium in the 1990s as a medium for sculpture. In 2013, he co-founded **MycoWorks** with Sophia Wang. MycoWorks first produced mycelium bricks for building and containers. Fine Mycelium™ is the company's patented process that engineers mycelium cells as they grow to create three dimensional structures that are densely entwined and inherently strong.

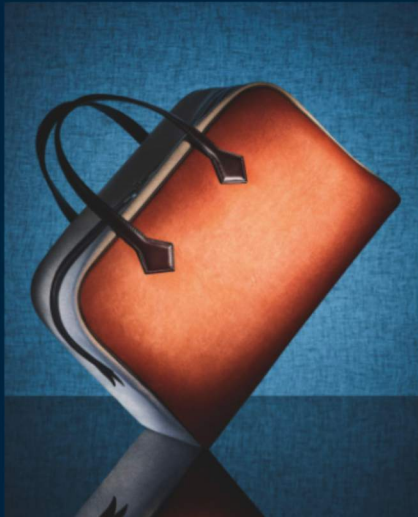
In February 2020, MycoWorks presented its pioneering material Reishi™ made with Fine Mycelium™ technology at New York Fashion Week. The material is said to match the strength and durability of cowhide. It can be custom-grown to partners' specifications for strength, drape, size, surface features and more, offering brands the unique advantage of total creative control over quality, performance, and aesthetics.

VICTORIA BAG IN SYLVANIA MADE OUT OF FINE MYCELIUM, H PLUME CANVAS AND EVERCALF CALFSKIN.

An Exclusive Collaboration by Hermès and MycoWorks

The new material Sylvania, a hybrid of nature and biotechnology, is the exemplar of a new generation of biotech materials.

It is an exclusive collaboration by Hermès and MycoWorks, and the first object made with Fine Mycelium, the patented technology from MycoWorks that enhances mycelium as it grows.



ANNOUNCEMENT OF COLLABORATION. MYCOWORKS

MycoWorks and **Hermès** entered into an exclusive collaboration in 2021 to create the first object made with Fine Mycelium™, the patented technology from MycoWorks that enhances mycelium as it grows.

The Hermès Victoria bag is made with MycoWorks' material, Sylvania. The mycelium is produced in the MycoWorks facility. It is then tanned and finished in France by the Hermès tanners to further refine its strength and durability, and shaped in the workshops by the Hermès craftsmen. Sylvania is said to be biodegradable and have a lower carbon footprint than animal leather.



MYCOWORKS

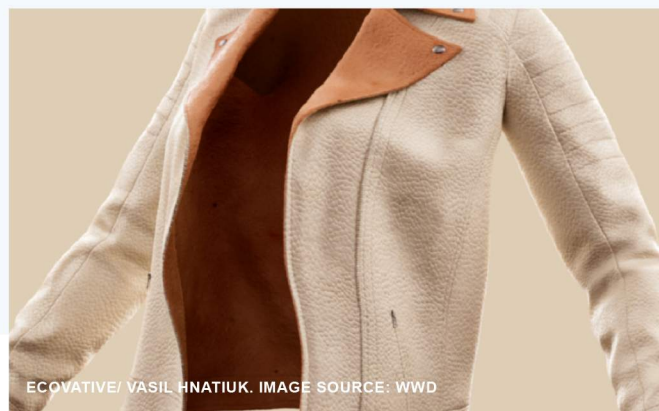


An up-and-coming company in the mycelium space is **MYCL Mycotech Lab**. The founders came together as gourmet mushroom producers in 2012. Inspired by tempeh, a traditional Indonesian dish, they began doing makeshift research using pressure cookers to grow new materials. In 2019, they ran a kickstarter campaign to scale up their leather alternative Mylea. Mylea is a next-gen leather made of blended mycelium and agroforestry byproducts. Mylea has been used by several designers and brands, including Japan's **DOUBLET** in the Paris Fashion Week SS22 collection.



Ecovative first developed and commercialized production of mycelium-based packaging called Mushroom® Packaging, which is used by a number of top brands. Investments and partnerships in 2011 allowed the company to increase their staff and open a 35,000 ft² (~3250 m²) Mycelium Foundry located in New York. Its proprietary AirMycelium™ vertical farms grow mycelium materials at industrial scale on agricultural waste. Forager™ Hides grow over 20 meters long by 2 meters wide in just 9 days from seed to harvest.

In December 2021, **PVH** and **Bestseller** announced the formation of new cooperative to trial Ecovative's mycelium "Forager" hides.



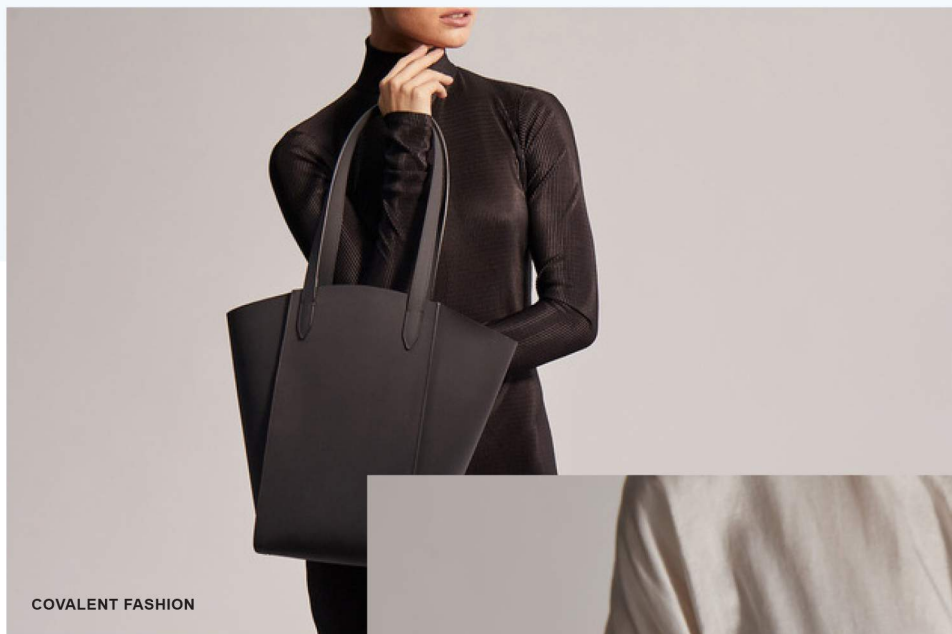
ECOVATIVE/ VASIL HNATYUK. IMAGE SOURCE: WWD

Concept jacket by Forager hides shows the mycelium leather as a product after collaboration with fashion brands and tannery partners.



The biotechnology company **Newlight** produces AirCarbon, a material made by natural microorganisms in the ocean that bond carbon and oxygen to make a carbon-negative material called PBH (polyhydroxybutyrate). The final material is a moldable biomaterial that can be used as an alternative to both plastic and animal-based leather.

In 2021, **Nike** entered into a relationship to explore materials from Newlight. In addition to being a material innovator and supplier, Newlight launched its own fashion brand **Covalent** to create products made with AirCarbon.





Louis Vuitton announced its new Charlie sneakers crafted from 90 percent recycled and bio-based materials. The fashion house incorporated Biopololi – a corn-based plastic – that will make its market debut with the Louis Vuitton shoes.⁵¹



Malai produces a biocomposite material of the same name from bacterial cellulose grown on agricultural waste sourced from the coconut industry in Southern India. That polymer is mixed with natural fibers (such as banana fiber, hemp fiber, and sisal fiber) for strength, and then bound together with natural gums and resins.

Malai has been used for footwear and accessories by a number of designers including **Eva Klabalova** and **Lucie Trejtnarova**, and brands including **Kazeto**, and **Libena Rochova**.



ScobyTec produces a next-gen material called ScobyTec BNC (Bacterial Nano Cellulose).

The company partnered with the brand **Ricosta** to produce the first industrially manufactured shoes for children made from bacterial cellulose and the German brand **FAIRschuh** to develop sneakers made from ScobyTec BNC.

Major Companies with Next-Gen Leather Offerings

Well established material companies are developing next-gen leathers, some by improving upon traditional synthetic leather by increasing its bio-based content. At MII, we promote “progress to perfection” and view any legitimate attempt to become more sustainable as a positive step for the industry. In this section, we highlight partnerships with major manufacturers that have a next-gen leather among their offerings.



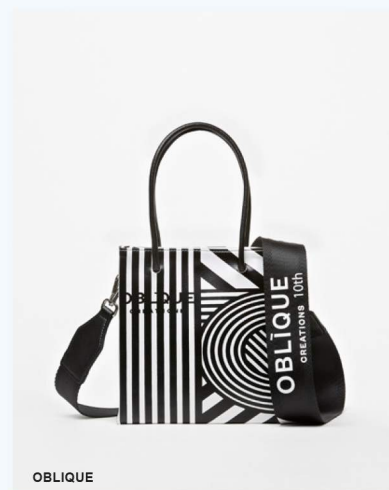
Panama Trimmings is an Italian company, manufacturing labels, straps, jacrons, and other trimmings since 1981. The company includes recycled and plant-based blends in their offerings. Their Viridis® material has been selected by a number of European brands for use in footwear and accessories.



Arkimedia, known for producing high quality watch straps, chose Viridis® to continue creating unique products for the world’s timekeeping companies, while meeting the demand for more sustainable products and protecting the environment.



The Swiss brand **etéreo**, founded in 2020, creates bags inspired by washable paper materials. As an expansion of their portfolio, they chose Viridis® to design a new sustainable and ethical bag.



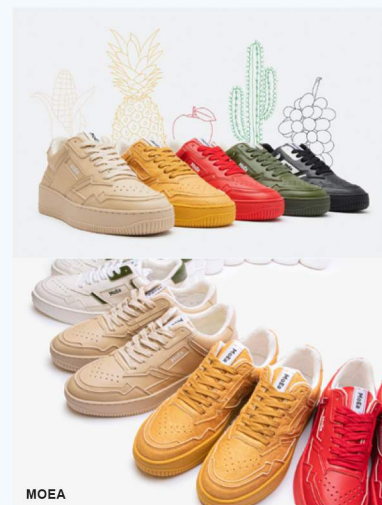
The Italian fashion brand **Oblique** chose Viridis® to create their ICON BAG in 2020. The bag celebrates the ten years of the brand, symbolizing a new stylistic challenge that combines creativity and innovation, ethics and aesthetics.



Jack & Jones, one of Europe's leading producers of menswear, and Cubus, one of Scandinavia's largest clothing chains, partnered with Panama Trimmings to create Viridis® jacrons.



The German sneaker brand **Genesis Footwear** partnered with Panama Trimmings to create shoes made from Viridis®.



MoEa partnered with Panama Trimmings and four other next-gen material companies to develop a line of sneakers made with plant components. In addition to Viridis® made from corn, the other materials use apple, pineapple, cactus, and grape as input.

'TORAY'

Since its debut in 1970, **Toray** has continued to improve and innovate their Ultrasuede® material, including the introduction of Ultrasuede® HP, used in furniture, automobile upholstery, and fashion. Ultrasuede® HP is made using partially plant-based polymers and has been selected by numerous brands for high performance products.



THAYER COGGIN

Furniture brand **Thayer Coggin** chose Ultrasuede® HP for the relaunch of the iconic piece "Sit Tight" by Milo Baughman. Ultrasuede® HP allowed the contoured shapes to be expertly accentuated.



MA ALLEN INTERIORS

Designer MA Allen of **MA Allen Interiors** chose Toray's Ultrasuede® HP upholstery for her Saporiti colorblock dining chairs. With three kids of her own, she affirmed the material is stain and abrasion resistant as well as durable.

Other Examples of Partnerships

Well established material companies are developing next-gen leathers, some by improving upon traditional synthetic leather by increasing its bio-based content. At MII, we promote “progress to perfection” and view any legitimate attempt to become more sustainable as a positive step for the industry. In this section, we highlight partnerships with major manufacturers that have a next-gen leather among their offerings.



Reformation CORONET

For over 50 years, Italian material company **Coronet** has produced and innovated in synthetic leather. Coronet's BioVeg is a USDA biopreferred next-gen leather made of cereal grains combined with textiles sourced from recycled materials.

In 2021, the Californian brand **Reformation** partnered with Coronet to launch footwear made with BioVeg.



Ultrafabrics launched Ultraleather® Volar Bio as a mark of the company's journey towards a sustainable future. The bio-based leather is made with wood pulp and corn by-products and was designed to look and feel like traditional animal leather.

FitBit used Ultraleather® Volar Bio in the 2021 introduction of their first vegan leather band option for two models.



FITBIT



LUXTRA LONDON FISCATECH

Italian company **Fiscatech** offers bio-based leather E-Ultra® that is used by London-based vegan luxury brand **LUXTRA**. The brand chose E-Ultra® because it is an appealing, durable and high performance material with a high bio-content (69%).

Special: The Automotive Industry

Demand for sustainable materials has also grown in the automobile industry. According to a survey conducted by Asahi Kasei Europe in October 2019, consumer desire for premium and sustainable surface materials is increasing. When asked about the interior of an automobile, “57% of the respondents think that sustainable materials for seat covers and surfaces will be becoming increasingly important in the next 5 to 10 years, while the need for real leather equipment will fall drastically”.⁵² These are some examples of partnerships between next-gen material companies and automotive brands.

Concept Cars



Adriano Di Marti, the Desserto® company, announced Deserttex®, an exclusive material developed for automotive applications. Deserttex® was launched in 2021 alongside the BMW Startup Garage program.



BMW's concept car which interior was made with Deserttex by Adriano di Marti.



BENTLEY

VEGEA's next-gen leather was chosen by **Bentley** for its new EXP 100 GT car seats. The electric concept car was created to celebrate the company's centenary year with sustainable materials. The collaboration demonstrates an environmental awareness in the luxury car market.



Bentley's EXP 100 GT interior made with VEGEA.



Mercedes-Benz

Mercedes-Benz's first all-electric EQS sedan, The Vision EQXX, uses **Deserttex®** and **Mylo™** next-gen leather for seating and interior spaces, and next-gen silk fabric on the doors created by **AMSilk** (see more about this company in the Next-Gen Silk section).





IMAGE SOURCE: VOLKSWAGEN NEWROOM

Volkswagen's ID. Space Vizzion interior made with AppleSkin™ by Frumat.



Frumat partnered with **Volkswagen** on the interior of the all-electric concept car Space Vizzion.

Frumat's AppleSkin™ leather is used throughout the cabin as well as for the seats. The German auto company hopes the innovation will soon be setting trends.



NATURAL FIBER WELDING

Porsche's door trim made with MIRUM® by NFW®.



In 2020, NFW® presented a pilot project in cooperation with the Indian automotive supplier **Motherson** for a **Taycan Porsche**. This project used NFW®'s MIRUM® for the door panels and other parts of the car interior.

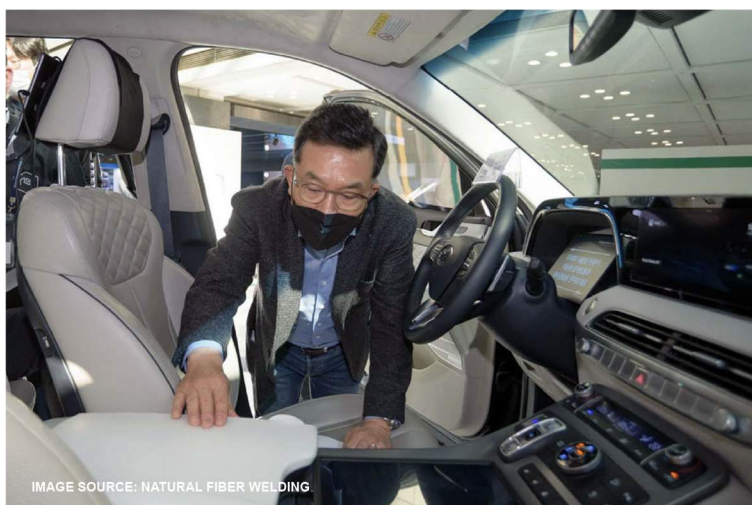


IMAGE SOURCE: NATURAL FIBER WELDING



In 2021, **Hyundai** also featured NFW®'s innovative technology at their Open Innovation Lounge automotive event. Eissmann Group Automotive used NFW®'s MIRUM® to create a center console and door panel prototype that were on display at the same event.

In the Market

MIKO



New VW model featuring seats upholstered in Dinamica®.



Defender V8 featuring Dinamica® finishes.

Miko, the Italian subsidiary of U.S.-based Sage Automotive, uses recycled polyester microfibers to create the material Dinamica® which, resembles suede. Initially used in the furnishing and fashion industries, Dinamica® has been gaining popularity in the automotive industry in recent years. **Mercedes-Benz, Volkswagen, Land Rover, Audi**, and other major car companies use Dinamica® for seats and headrests, door panels, and steering wheels.

In-House Innovation



Volvo is moving away from bovine leather with the next generation of Volvo models. The new material, called Nordico, was created by Volvo and consists of textiles produced from recycled PET bottles, recycled cork, and biomaterials sourced from forests in Sweden and Finland. This move comes because of the environmental impacts of cattle farming. Volvo hopes this will become a new standard for premium interior design.



Volkswagen wants to avoid using any animal products whatsoever in their electric cars. In line with that decision, Volkswagen is currently developing "coffee leather" for its ID. electric car family. In particular, Volkswagen is experimenting with using coffee silverskin to increase the percentage of organic materials in imitation leather. The company expects that using this new material in series production is a possibility in the next few years.



Next-Gen Down

Introduction

The “current-gen” alternative to down is typically made with polyester microfiber that simulates the pillowy feeling of feather or down at a fraction of the cost. In contrast, next-gen material innovators use plants, recycled PET, and other more sustainable input to create alternatives that are both animal- and planet-friendly.

PANGAIA and **Save the Duck** are retail brands as well as material innovators with a business-to-business (B2B) line that sells their next-gen down to other brands. As in next-gen leather, several major material suppliers that include next-gen down as one of their offerings are also featured.



PANGAIA is both a direct-to-consumer materials science company and a B2B platform. The company has over 200 fabrics and innovative materials in its portfolio, which it brings to market through PANGAIA-branded designs and products as well as via partnerships with other brands.

One of its proprietary materials is FLWRDWN™, a down-fill material made using a combination of wildflowers, a biopolymer, and aerogel. According to PANGAIA, wildflowers that directly support habitat conservation are used and are grown without any pesticides or artificial irrigation. The biopolymer is made from corn and is fully compostable. The patented biodegradable aerogel - over 10 years in development - increases the performance and durability of FLWRDWN™ products. FLWRDWN™ is used to produce Pangaia's jackets, vests, and accessories and is made available to other brands via the B2B platform PANGAIA Science.



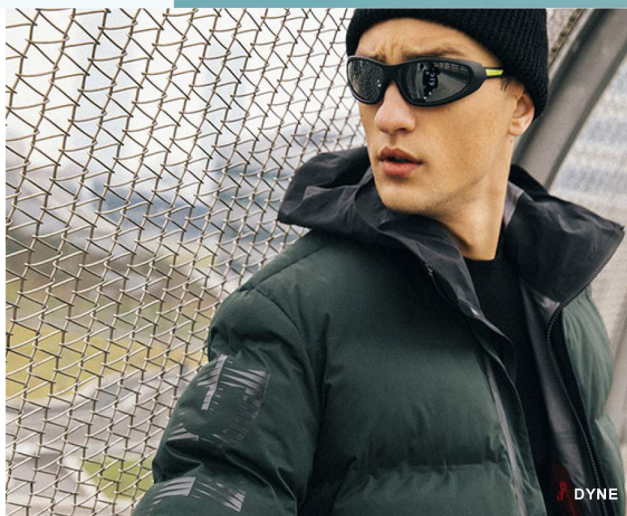
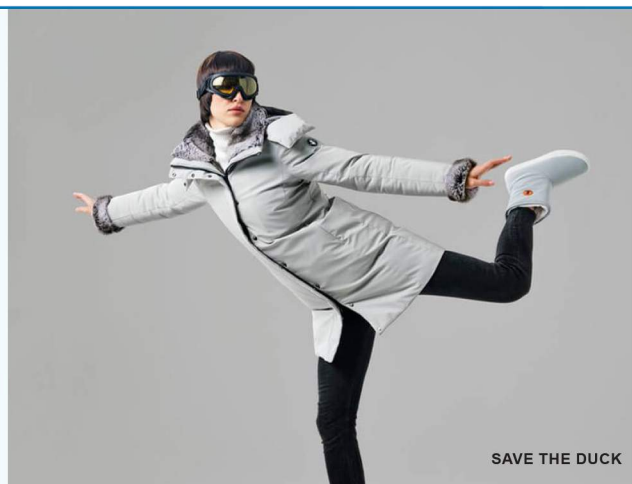
H&M launched a collection featuring alternatives to animal-derived fabrics and processes, including FLWRDWN™. The next-gen material from PANGAIA was used to make puffer shoes, animal print bags, and children's puffer jackets in exuberant hues. The Co-Exist Story collection marks the third installment in H&M's Innovation Stories initiative, first launched in early 2021 with the theme Science Story, followed by Colour Story.



H&M



The animal-friendly outerwear brand **Save The Duck** created the feather-free filling PLUMTECH® in 2014 and has continued to innovate in this space. Their RECYCLED PLUMTECH®, made from recycled plastic bottles, was launched in 2018. Save The Duck uses this next-gen down in their own products and has been part of numerous partnerships with designers and brands, including with **Disney**, **Dyne**, and others. Image shows Save The Duck dog coat in collaboration with Milan-based company **United Pets**, made with recycled Plumtech®.



Disney

In 2018, Save The Duck collaborated with **Disney** to launch jackets for men, women, and children made with Plumtech® filling and dedicated to the most famous ducks in the world, Donald and Daisy. Each jacket contained an exclusive comic strip on the inside with an environmental message.

DYNE

In 2019, The New York brand **Dyne**, founded by Christopher Bevans, created micro-puffer jackets and rainwear featuring Plumtech® from Save the Duck.

Major companies with next-gen down offering

As in the next-gen leather space, a number of major companies have introduced a next-gen down material among their offerings, generally made from post-consumer recycled PET.

3M™ Thinsulate™ Featherless

The original Thinsulate™ Insulation from 3M was launched in 1979 and widely used as insulation in outerwear. In 2015, 3M™ developed Thinsulate™ Featherless Insulation in partnership with the performance outerwear company **Marmot** as a kinder alternative to feather down. 3M™ Thinsulate™ Featherless is a loose-fill insulation made from 100% post-consumer plastic bottles.



PrimaLoft® Bio™

PrimaLoft originally developed PrimaLoft® insulation for the United States army as a water-resistant down alternative. In 2018, the company introduced PrimaLoft® Bio™, a 100% recycled synthetic insulation and fabric. PrimaLoft notes that in the right conditions, PrimaLoft® Bio™ breaks down at an accelerated rate, completing full biodegradation in a matter of years. This new approach to sustainability led to partnerships with dozens of brands in the fashion industry, including **Bleed**, **Horsefeathers**, **Jack Wolfskin**, **Klättermusen**, **Norrøna**, **Roeckl**, and many others.

Thermore Ecodown®

Since their founding in 1972, Thermore has been an innovator in thermal insulation. The company manufactures a range of down alternative fibers for the outerwear market. The Ecodown® product line, made exclusively from post-consumer PET water bottles, was launched in 2018. Numerous brands have chosen to use Ecodown® as a way to reduce their reliance on virgin polyester while maintaining warmth, weight, and other desired performance characteristics. Ecodown® is offered in a variety of weights and thicknesses, is durable, and does not require special quilting restrictions.

In 2018, Thermore partnered with the children's apparel brand **Chicco** to create children's jackets quilted with Ecodown®. This initiative was part of Chicco's goal of making children's fashion more sustainable.

In 2019, American outerwear brand **Timberland**, German brand **Fuchs Schmitt**, and luxury brand **Marc O'Polo** chose Ecodown® as part of their commitment to sustainability. Similarly, the slow fashion brand **Culthred** chose Thermore's Ecodown as insulation and padding for their coat collection in 2020. Most recently, the brands **Nike** and **Stüssy** partnered to launch a hooded jacket and pants made with Ecodown®.





Next-Gen Silk

Introduction

Often called the “Queen of Fibers,” silk has long been one of the most sought after and highly valued fabrics. Approximately 160,000 metric tons of silk are produced annually with seriously troubling environmental, animal protection, and human rights consequences. For example, studies have shown that the silk production process can require an exorbitant amount of water (up to 20 household pools per ton of silk produced)⁵³ and up to 20 kg of firewood must be burned to generate 1 kg of raw silk.⁵⁴ According to the Higg index, silk has the highest environmental footprint across impact categories compared to any other category of material including cotton, nylon, and wool. In addition to alleviating environmental concerns, material innovators are reinventing silk to overcome performance limitations inherent to the material.



ORANGE FIBER

Orange Fiber, founded in 2014, is an Italian company that has patented the process to produce fibers and fabrics from citrus fruit by-products. The cellulosic fiber is harvested from citrus waste from orange juice production, upcycling potential waste materials that otherwise would have been discarded. Orange Fiber has received funding and awards from a number of European brands, NGOs, and government programs. In October 2020 the company completed the creation of a new plant in Sicily and produced its first ton of fiber.

Salvatore Ferragamo

Salvatore Ferragamo was the first fashion house to employ Orange Fiber fabrics. In 2017, Salvatore Ferragamo launched a capsule collection of shirts, dresses, trousers, and scarves made with Orange Fiber. Exclusive Mediterranean-inspired prints were created to be in sync with the origins of the fiber.



SALVATORE FERRAGAMO



SALVATORE FERRAGAMO



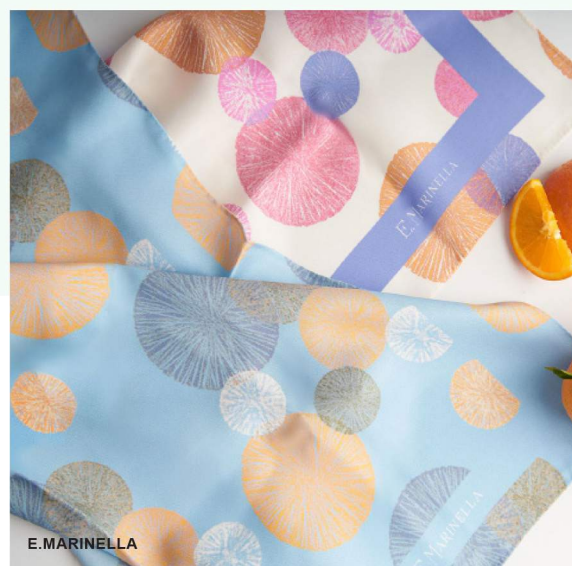
H&M

H&M chose Orange Fiber for its Conscious Exclusive 2019 premium collection, made with recycled and sustainable materials. Orange Fiber was used to create a sophisticated boho-style top that sold out within a few hours of becoming available online and in selected stores. The collaboration between H&M and Orange Fiber began in 2015 when Orange Fiber won H&M Foundation's Global Change Award.




E. MARINELLA
 NAPOLI

Since 2019, historic Neapolitan luxury brand **E. Marinella** partnered with Orange Fiber to create an exclusive collection of sustainable ties, pocket squares, and scarves available in its flagship stores and e-shop. Proud of their tradition of making products "always in pure silk", **E. Marinella** acknowledges that the Orange Fiber fabric has silky texture, and that the collection represents the ability to evolve while maintaining the brand's values. In 2021, the **E. Marinella**/Orange Fiber collection was chosen as the official gift of the Italian-led G20.





AMSilk a German biotech company founded in 2008, launched Biosteel® fiber in 2013. Biosteel® is spider silk protein produced by genetically engineered microbes and spun into fiber. The material offers a unique combination of properties that are crucial in performance, such as being 15% lighter than conventional synthetic fibers. It is also fully biodegradable.



AMSilk and **adidas** announced their partnership at the renowned Biofabricate Conference in New York in 2016. AMSilk's Biosteel® fiber was used in the **adidas** Futurecraft Biofabric high performance shoe.



In addition to next-gen leather Mylo™ (see Next-Gen Leather section), **Bolt Threads** also developed and brought MICROSilk™ to market in 2012. The material seeks to replicate spider silk fibers sustainably and at a large scale. Through bioengineering, Bolt Threads developed proteins inspired by spider silk. The proteins are produced in large quantities through fermentation, using yeast, sugar, and water. Silk proteins are then isolated and spun into fibers.



MoMA Dress by Stella McCartney



Tennis Dress by adidas and Stella McCartney

STELLA McCARTNEY

The first collaborative product **Bolt Threads** made with MICROSilk™ was by designer **Stella McCartney**. It was shown at the New York Museum of Modern Art (MoMA).

STELLA McCARTNEY



Stella McCartney and **adidas** created a Biofabric Tennis Dress made with MICROSilk™. The microbe-derived material is mixed with a cellulose-blended yarn to make the prototype dress.



Spiber is a Japanese biotechnology company developing synthetic spider silk without the use of animals or petroleum resources. Spiber uses synthetic biology to produce protein polymers inspired by nature called Brewed Protein™ that are then purified, spun into threads, and woven into fabrics.

The company is currently constructing the world's largest structural protein fermentation facility in Thailand. With this expansion, Spiber aims to manufacture sustainable protein-based materials at a competitive cost. Commercial production of synthetic spider silk is expected to start in 2021, with a production capacity of several hundred tons per year.



Along with **The North Face** Japan, Spiber announced the Moon Parka, the world's first high-performance outdoor jacket made from proteins. The apparel's fabric is a potential replacement for petroleum-based fabrics like polyester and nylon.

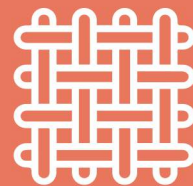


YUIMA NAKAZATO

Yuima Nakazato presented a *couture* collection for Fall/Winter 2019/20 at Paris Fashion Week in collaboration with Spiber. This collection embodies Yuima Nakazato's declaration that "*Haute couture* is inherently sustainable." Each piece in the collection utilizes Spiber's newly-developed, sustainable Brewed Protein™ material to manifest the brand's vision of *haute couture* and the role they believe it should play—to build a more sustainable relationship between humankind and the environment.



BERGANS



Next-Gen Wool

Introduction

The wool industry is at a fraction of its 1990 peak. Wool has increasingly been replaced by cheaper and highly adaptable synthetics and cotton blends. The next paradigm shift is likely to be inspired by more than lowering costs, but rather by creating alternatives that are more sustainable for people, animals, and the planet. Next-gen companies have found in PET and plants a new way of producing yarn with wool-like properties.

As in the other next-gen categories, some companies in this section market their products as next-gen materials, not specifically as next-gen wool.



Spinnova creates wool-like textile fibers directly from FSC-certified wood and waste streams. Using their proprietary technology, the company mechanically refines pulp raw material and transforms it into a spin-ready fiber suspension with non-toxic chemistry. The wood pulp flows through a unique nozzle, where the fibrils rotate and align with the flow, creating a strong, elastic network. The fiber is then spun and dried, at which point it is suitable for spinning into yarn and then knitting or weaving into fabric.



The Collection of Tomorrow by Spinnova x **Bergans** was awarded the ISPO Sustainability Achievement Award 2020. The collection is part of a limited subscription-based process: the consumer purchases and uses the product, and then takes the item back at its end of life for the production of a new piece. **Bergans** and Spinnova are working together on a long-term product development collaboration.



marimekko®

Finland's design house **Marimekko** partnered with Spinnova in 2019. The woven and the jersey fabric used in these products were made of the Spinnova fiber combined with cotton and/or lyocell. The demo products showcased the versatility of Spinnova fabric to also create denim-like designs.



The **H&M Group** announced a partnership with Spinnova in 2019. The H&M Group believes Spinnova fiber will be the breakthrough that the textile and fashion industry has been waiting for because of its high quality product, scalable technology, and ample sustainable supply of raw material.

BESTSELLER

Spinnova and the multi-brand retailer **Bestseller** partnered in 2020 with the goal of creating the world's most sustainable fabric. Bestseller has built an innovative Fashion FWD Lab to focus on new, low-impact, and circular materials, better production, new business models, and smarter ways of manufacturing. The brand claimed Spinnova is a good fit to be part of their project of creating a climate positive future, fair for all and circular by design.



In 2021, Spinnova entered into a partnership with the global outdoor apparel leader **The North Face** to develop new, sustainable, high-performance textiles. The North Face chose Spinnova because it is produced without harmful chemicals, with minimal water usage, and with minimal CO2 emissions. It also does not contain microplastics and has the potential of being fully circular.

FABORG

India-based Faborg has developed a mix of organic cotton (70%) and *Calotropis gigantea* plant (30%) to produce their Weganool™. *Calotropis* is a plant that thrives on drought-prone and depleted soils and requires virtually no water or pesticides to grow. Producing Weganool is a scalable community project that creates zero waste, restores biodiversity and soil fertility, and fights poverty in rural areas of India.



Infantium Victoria X Weganool capsule collection.

INFANTIUM Victoria

Luxury vegan childrenswear brand **Infantium Victoria** launched the first commercially available line of Weganool products that included a hoodie, a baby jacket, and a festive gown for girls. The brand stated that finding a material that will keep warm and cozy without synthetics was “the most prominent design challenge” for them until they found Weganool, and said that this fabric could potentially replace synthetic fibers and become the staple in sustainable fashion design.



Eco Simple

Brazilian company **EcoSimple** has developed high performance textiles made from recycled materials, and a dying process that uses the natural color of the wastes themselves, without the need for chemicals or water. Each meter of EcoSimple fabric eliminates about 500 grams of textile waste and 8 PET bottles from the environment. Their materials have been used in several applications, including the catwalk fashion collection by **Alexandre Herchcovitch**, footwear by handmade brand **Dotz**, and interior design pieces by **Tok Stok**.

osom

Patricia Ermecheo, inspired to upcycle waste fabrics, founded **Osom Brand** to respin waste fabrics from donated clothing, deadstock, or other unwanted materials into recycled yarn. The company's upcycling process does not use water or dyes, and the shredded fabrics are kept in their original colors. The re-spun threads are water resistant and flame retardant and come in several yarn counts, customizable by material, weave, and color. Osom Brand currently sells Osomtex socks, shirts, sweatshirts, and towels through their website, but they have collaborated with other brands to provide socks for specific occasions as well as re-spun material for new products.



NIKE



Osom Brand partnered with **Nike** to design what has been called the most sustainable footwear ever. For the basis of their Space Hippie collection, Nike chose what they called 'Space Waste Yarn' from Osomtex by Osom Brand, made from 100% recycled material, including T-shirts and yarn scraps. When combined with the other elements of the shoe, the upper contained 90% recycled content by weight.

STELLA MCCARTNEY

Stella McCartney has also collaborated with Osomtex to bring to life an upcycled, special-edition invitation sock for the Winter Défilé in Paris. The colorful socks, made with 85% upcycled yarn, were used as humorous twist puppets in promotional videos posted on Stella's social media.



STELLA MCCARTNEY

In Q1 2019, Reformation and Osomtex announced a strategic partnership to upcycle fabric scraps at Reformation's Los Angeles factory. The companies are further integrating circularity in the fashion industry by upcycling Reformation's fabric scraps into new yarn and fabrics, instead of into landfills. According to Reformation's Q1 Sustainability Report, the partnership's impact so far has seen 12,513 lbs of fabric scraps upcycled. An equivalent to saving 284,796 lbs of CO2 and 1.2 million gallons of water.



OSOMTEX



HOUSE OF FLUFF



Next-Gen Fur

Introduction

With over twenty and counting countries around the world implementing total or partial bans on fur farming and sale,⁵⁵ the market for faux fur is growing and is expected to continue. Brands that have pledged to never use animal fur include Gucci, Versace, Burberry, Armani, Ralph Lauren, Michael Kors, Vivienne Westwood, and many others.⁵⁶ As consumers begin to question the impact of faux fur on the environment, material innovators are increasingly creating next-gen versions by adding bio-based and/or recycled materials to their formulations.



Ecopel has created KOBA® Faux Fur made with plant-based fibers and recycled polyester, creating a fur that is soft, versatile, and long-lasting. Production consumes up to 30% less energy and produces up to 63% fewer greenhouse gases than conventional synthetics.



STELLA McCARTNEY

ECOPEL partnered with **Stella McCartney** to create the new KOBA® Fur Free Fur, the first prototype was revealed in 2020. The collection was praised as not only ethical, but also planet-friendly. Image above featuring Anna Wintour in Stella McCartney KOBA coat.



APPARIS

A year after the launch of KOBA® bio-based fur with Stella McCartney, ECOPEL partnered with the French faux fur mill Peltex to create Cannaba wool, a next-gen material made of blends of hemp and recycled fiber that results in a fur with a wooly look. When New York-based brand **Apparis** launched a plant-based outerwear capsule collection aimed toward 100% sustainable and vegan practices, it utilised both KOBA® Faux Fur and Cannaba vegan wool from Ecopel in its designs.



Lenzing has been producing fibers made from wood since 1892 and their lyocell technology is an important innovation in the production of cellulose fibers. As a producer of pulp and fibers, Lenzing is at the beginning of the value chain for the production of textiles and nonwoven products. The company seeks to work with partners, including fashion brands, to develop solutions that add more value to their products.

Tencel™ is Lenzing's flagship brand for textiles and their fibers can be blended with many other types to enhance performance and aesthetics according to the chosen application. Tencel™ Lyocell fibers are extracted from sustainably grown trees using a proprietary closed loop system. The soft, smooth, and silk-like cellulose fibers are utilised as replacements for wool, silk, down, and other materials.



The British brand **Jacaranda** carpets and rugs uses Tencel™ as a key fiber in their hand woven carpets and rugs. **Jacaranda** cites many benefits of Tencel compared to silk or wool, in particular that Tencel carpets and rugs manage indoor moisture, harboring fewer bacteria for a healthier living environment, and they can be professionally cold wet cleaned.



UGG used Tencel™ as a fur-like upper in their sustainable line, the Plant Power Collection, launched in 2021. The collection includes three distinct shoes—the Fluff Sugar Platform, the Fluff Sugar Sandal, and the Neumel Natural, which is a vegan take on the California-based brand's best-selling Neumel chukka boot. The Fluff Sugar Platform and the Fluff Sugar Sandal are vegan versions of the shoes in UGG's wildly popular fluff franchise. UGG shoes are typically made from sheepskin. This new line builds on FEEL GOOD, UGG's sustainability platform that was launched in October 2020.

B. Via In-House Material Innovation

Some brands transition to next-gen materials by developing in-house materials. One of the advantages of in-house material innovation is exclusive access. Significant investments are required for research and development to create a new material, and having full control over a material that best fits a brand's needs, priorities, and constraints can make the investment worthwhile.



GUCCI

After two years of in-house development, Gucci created the next-gen leather material Demetra. Demetra is composed of bio-based polyurethane, viscose, and sustainably-sourced wood compounds. Demetra is produced using Gucci's own leather tanning procedures, offering customers a markedly similar leather experience in terms of aesthetics, suppleness, and resistance to the elements. Demetra is currently used to craft Gucci's own products, but the brand is open to selling to other labels in the future. To kick off the announcement, Gucci offers three men's and women's sneaker models made from Demetra.



JORD®

The American sustainable-focused brand **JORD** has developed its own vegan leather called Suberhide™. It uses a proprietary process that involves fusing a polymeric layer over agglomerated natural Portuguese corks, transforming a natural material into a tough yet adaptable, soft leather.

VON HOLZHAUSEN

California-based luxury bags brand **von Holzhausen** has developed two next-gen materials. Banbū Leather was created with bamboo and is 5 times lighter than traditional leather. Technik-Leather is made from recycled plastic water bottles and is resistant to stain, water, and scratches. The brand uses both materials to produce its products.



HOUSE OF FLUFF



"We have always believed in good as a way to greatness. Sorona was the first big step towards creating a more earth friendly animal-free fur. Our goal at House of Fluff is to go even farther to create the cleanest biosynthetic textiles possible. We will not rest until we achieve the highest level of biodegradability and rid our textiles of petroleum, this is what we see as greatness!"

Kym Canter, Founder of House of Fluff



House of Fluff is an established non-animal fur fashion label that developed and launched its own material BIOFUR™ in 2020. BIOFUR™ is made from a corn polymer and recycled polyester that has been treated to decompose if it should end up in a landfill or the ocean. The goal is to go completely petroleum free in the near future. House of Fluff is also working on animal-free fox fur made without acrylic fibers.

C. Via Investment

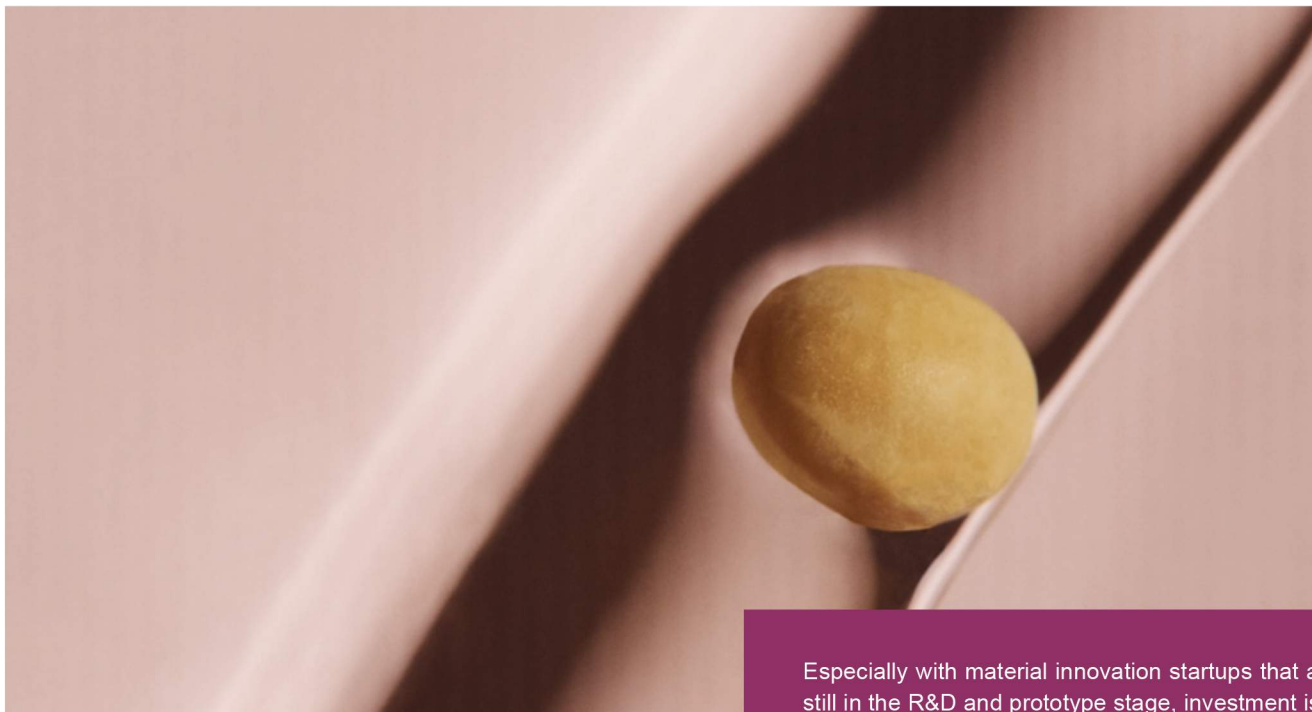
Some brands choose to invest in material innovation startups. In this section, we list examples of brand investments from publicly available information. Some of these are not only investor/investee relationships, but the beginning of a strategic partnership that allows brands to get early or even exclusive access to new materials.

SUSTAINABILITY / MATERIALS

Why Allbirds Is Investing \$2 Million in Natural Fiber Welding

Allbirds' "Plant Leather," is a market signal to bio-based leathers amid the climate crisis.

By KALEY ROSHITSH FEBRUARY 25, 2021, 6:00AM



Closeup of ingredients to make "Plant Leather", an innovation from Natural Fiber Welding and Allbirds.

An article in WWD discussing Allbirds' investment in Natural Fiber Welding in early 2021.
Source: WWD.⁵⁷

Especially with material innovation startups that are still in the R&D and prototype stage, investment is a great way for brands to get in the game early, even if a material is not yet ready for production. This kind of early strategic partnership is also beneficial for the material innovators as they develop and pivot through the early stages of their startup business.



Elaine Siu
Chief Innovation Officer,
Material Innovation Initiative



Capri Holdings Limited acquired 30% in Desserto® (2021)

Capri Holdings Limited (formerly Michael Kors Holdings Limited) acquired a 30% stake in Adriano Di Marti, the company behind cactus-based leather Desserto® based in Mexico. Capri Holdings Limited highlighted this investment in its 2021 CSR report as a realisation of its 2020 pledge to explore innovative and environmentally responsible materials.⁵⁸



Adidas subscribes €3 million in Spinnova's IPO (2021)

In 2021, adidas agreed to purchase 3 million euros (USD \$3.65 million) worth of shares in Finland's Spinnova initial public offering. The strategic partnership is to secure access to a significant volume of the company's patented fiber in the future, and meet the goal of using only recycled polyester by 2024.⁵⁹ In addition to adidas, ECCO Holding A/S and Lenzing AG had a holding of 0.77 percent and 4.68 percent in Spinnova immediately after the initial public offering.⁶⁰



BMW i Ventures invested in NFW's \$15M venture round (2021)

BMW i Ventures announced an investment in Natural Fiber Welding (NFW). The financing round will enable the company to scale from the batch processing of materials to commercial roll-to-roll production. In addition to the investment by BMW i Ventures, BMW Group also announced its intention to form a strategic partnership with NFW to further its own sustainability goals.⁶¹ BMW Group has set ambitious sustainability targets as it aims to reduce CO2 emissions along the entire value chain. To achieve this, the company primarily seeks to make use of recyclable materials, or materials that have a lower carbon footprint, while still retaining the same high functionality, aesthetics, and premium quality. In addition to BMW i Ventures, Allbirds also invested \$2 million in NFW in 2021.



Asics Corporation invests in Israeli next-gen silk startup Seevix Material Sciences (2020)

Seevix Material Sciences is a next-gen company established in 2014 that produces a patented animal-free silk SVX™. Produced in a controlled fermenter-based process, SVX is a natural biopolymer that is thinner, lighter, and tougher than traditional silk. Asics Corporation's investment arm Asics Ventures invested in and is collaborating with Seevix to develop its next-gen sportswear. In addition to collaborations with additional multinational market leaders, Seevix has already begun sales of its SVX-based SpheroSeev, used by laboratories throughout the world for tissue modeling, cancer research, 3D bioprinting, and cultured meat. Marketing of Seevix's revolutionary SVX-based skin and hair care products is expected to begin in 2022.



Toyota Boshoku invests in Japanese Brewed Protein company Spiber (2017)

Toyota Motor-affiliated parts manufacturers Kojima Industries and Toyota Boshoku have invested in the Japanese next-gen material company Spiber. The startup, which developed the animal-free silk Brewed Protein, is set to begin full-fledged production in Thailand, a hub of the automotive industry. The capacity of production at the new plant is two orders of magnitude greater than the pilot site in Japan. Spiber completed its private equity round in September 2021 led by The Carlyle Group and has raised close to USD \$1 billion in total since 2013.



3M participated in Ecovative Design's USD \$14 million funding round (2013)

Ecovative Design raised USD \$14 million in equity financing. Among the investors is the technology and manufacturing conglomerate 3M Company, which has already invested in the company two years prior. 3M believes Ecovative is a kind of disruptive, breakthrough technology that can be a game-changer in various industries including automotive, and that they expected the partnership to enhance 3M's footprint in sustainable polymer technologies.

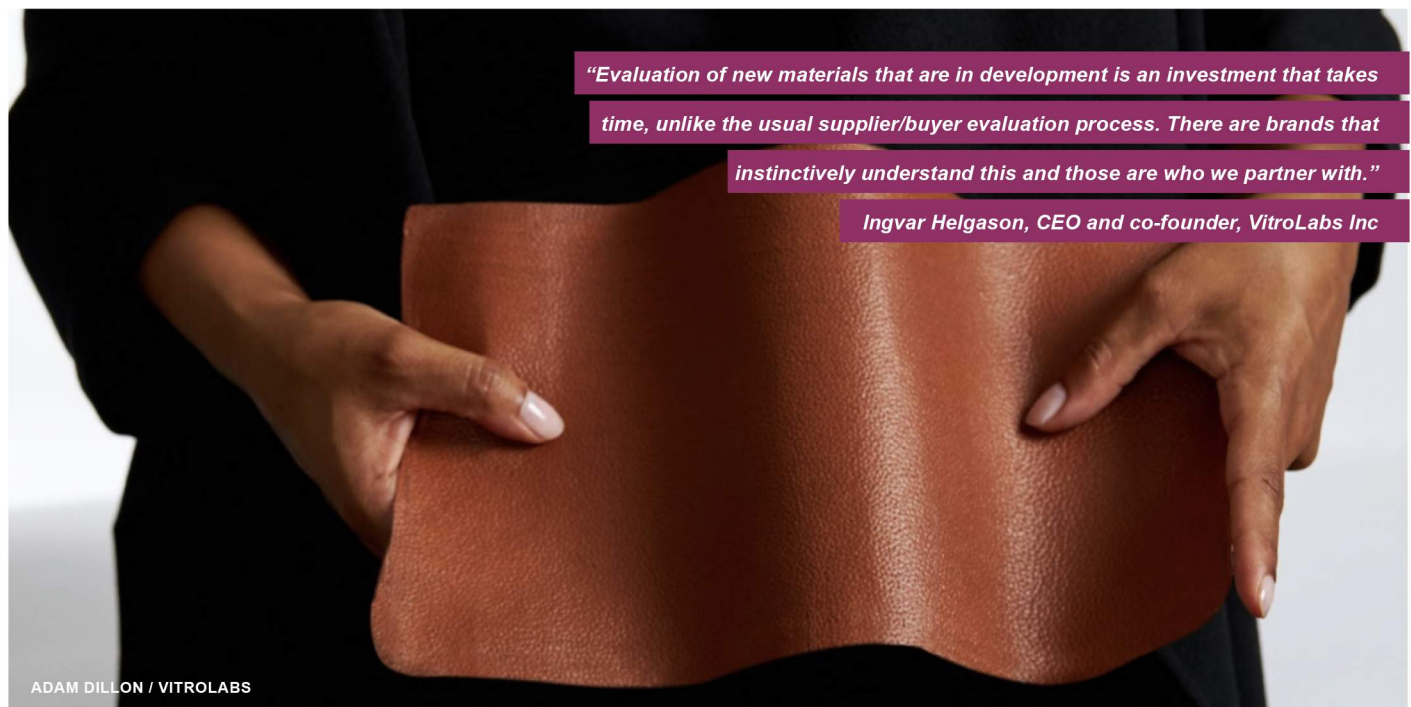
Special: Real Leather Without the Cow

Tissue engineering principles are being used to grow leather made from animal cells without the need to raise and slaughter an animal. Although there are not yet any materials on the market made from cultivated animal cells, we think this is an important technology to watch.

Is there such a thing as “too early” for brands to engage with new technologies and material innovators? When it comes to cutting edge technology like cultivated animal skin, brands are investing and engaging beyond the traditional sense.

VitroLabs Inc

The California-based company VitroLabs is developing a next-gen material made from ‘real’ animal cells. The process involves a harmless biopsy taken from a living animal, and then the cells are nourished with the nutrients needed to grow into an animal hide. After a few weeks, when the growth phase is complete, the hide can go directly to a simplified tanning step. This creates a significant reduction in the leather’s environmental impact.



According to Helgason, brands can bring resources and expertise to the table to guide product development. Given the novel nature of materials made from cultivated animal cells, brands can use their deep knowledge of the markets and play a crucial role in educating consumers and accelerating market adoption.

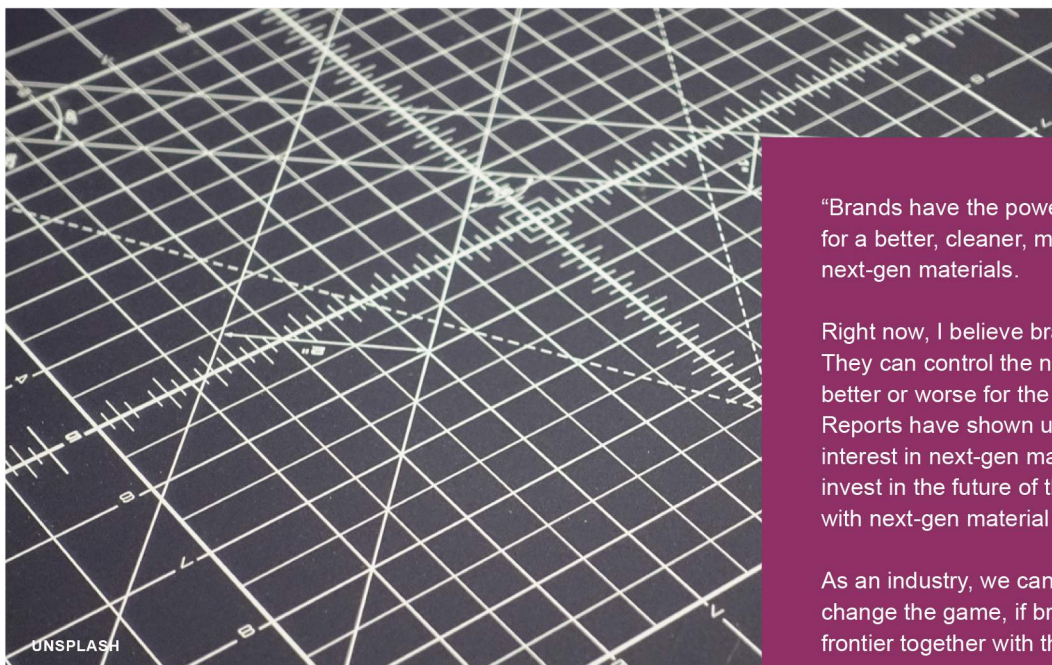
D. Via Providing Advisory Services

Another way for brands to influence next-gen materials is to provide advice to material companies on performance and aesthetic needs. Advisory services can benefit both brands and material companies and help accelerate the entire industry.

As experts in evaluation and use of materials, brands can provide valuable advice to material companies. Brands routinely have proprietary requirements for performance and aesthetic metrics that materials must meet. Next-gen material companies, especially new startups and small companies, do not always have design experience among their staff. Next-gen material companies can benefit greatly by receiving feedback from brands on their material as they progress through R&D.

Providing advisory services can benefit the brand in several ways. The first benefit is receiving behind-the-scenes insight into the progression of the industry. Second, the brand can compare products and find out early when next-gen materials will be ready for market. By developing relationships with material companies and helping with their progress, a brand is also in a good position to receive first access. As supply will initially be limited, early access can make the difference between a brand receiving a next-gen material contract or not.

Such advisory relationships are generally executed under non-disclosure or confidentiality agreements, and thus we cannot speak to common contractual terms. Of course, no one benefits when subpar next-gen materials enter the market. We encourage brands and material companies to enter into multiple advisory relationships in order to ensure both sides have a diverse and expanded understanding of market requirements and development.



“Brands have the power to communicate their ideals for a better, cleaner, more sustainable future through next-gen materials.

Right now, I believe brands are in the driver's seat. They can control the narrative of making things better or worse for the planet by their choices. Reports have shown us there is huge consumer interest in next-gen materials. Now is the time to invest in the future of their businesses by working with next-gen material makers.

As an industry, we can't move the needle, we can't change the game, if brands don't blaze this new frontier together with the innovators.”



Thomasine Dolan
Fashion Design Specialist
Material Innovation Initiative



PART III

Sourcing Tips

For brands that value sustainability and animal welfare, working with next-gen materials can provide great value. For brands with little experience sourcing materials from a developing industry, this section sets reasonable expectations for sourcing in this industry for at least the next few years. The more brands are prepared for what to expect, the easier the transition will be.

In an interview with *Business of Fashion*, Ganni's head of sustainability Lauren Bartley shared the challenges of using Vegea for a new shoe collection. The design team cycled through samples and stress-tested the material's durability over an 18-month development period. As a relatively long-standing material company, Vegea has plenty of experience working with brands. According to Bartley, other leather-like innovations she had encountered are further behind, and even securing swatches can take anywhere between six weeks and six months. From the outset, some options don't meet the brand's standards for look and feel. Internally, Ganni employees commonly refer to the tension between balancing strong design and commercial appeal with sustainability goals as "the beautiful struggle." Despite the challenges, the Danish brand is committed to stop using virgin leather by 2023, even though leather goods accounted for about 20 percent of sales in 2020.

The New Challenges

1.

Most next-gen materials are still in research and development and not yet on the market.

MII is tracking over 100 next-gen material companies,⁶² but fewer than 20% are currently in commercial scale production. The majority are in the early concept stage, conducting R&D, in prototype production, or building production facilities. Fashion, home goods, and automotive brands need to consider how to partner with material companies in their stage of development. For example, an early stage company may need advice and investment but will not be ready to sell materials. Although not all next-gen material companies in the industry will survive, many will continue through the development process and have exciting new materials for brands to explore.

2.

"The material company won't get back to me!"

Most next-gen material companies in their early stages are putting most of their resources into R&D and rarely have marketing or sales teams. This often makes it difficult for them to answer all inquiries from brands. In this situation, we recommend that brands send more than a blanket inquiry and instead express how the brand can help. Are you willing to partner on material development? Are you willing to invest? Would you offer advisory services? Or are you looking to purchase materials when they are ready?

3.

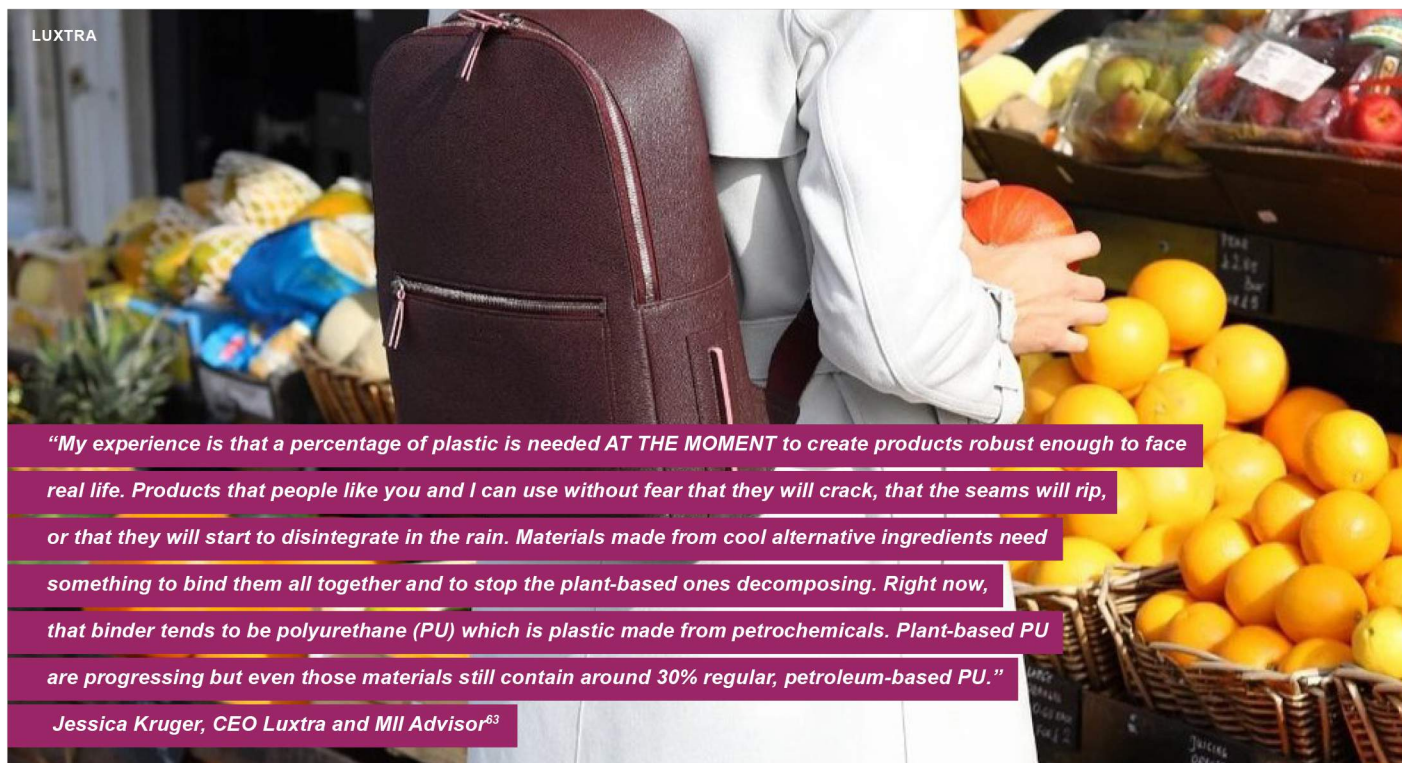
Next-gen materials are not “plug and play” replacements.

We believe next-gen materials will eventually replace all materials made from animals, but many of the next-gen material companies do not advertise their materials as direct replacements. This is because most next-gen materials do not currently meet all of the performance criteria currently expected by manufacturers and brands from animal materials. Most next-gen materials will not be a “plug and play” replacement for animal-based materials and process tuning will be required in manufacturing. We encourage brands to loop in their manufacturers early in the process or hire a manufacturer experienced in next-gen materials for the next-gen collection. We also encourage brands to consider whether the internal performance metric for specific materials in specific applications is actually necessary. If materials are to be biodegradable and recyclable at the end of life, they may not need to last as long as they currently do.

4.

Next-gen materials will consistently improve.

Most next-gen material companies go to market with a minimum viable product while continuing to refine and improve the performance, esthetic, and environmental impact of their material. For example, in order to meet important performance metrics, many next-gen materials contain some percentage of PU in their formulation. The overall environmental impact of even next-gen materials with some percentage of PU is still expected to be much lower than animal-based or 100% PU materials. Although these blends are difficult to recycle, an improvement in the sustainability at the material creation stage is a significant improvement on the overall sustainability of the material. We believe in making **progress with the goal of perfection; perfection should not be the enemy of better**. Next-gen material companies continue to improve their formulations, and next-gen materials available in 6 months are likely to be better than those currently available.



5.

Next-gen companies have limited swatches, yardage, and colors.

Fashion brands, especially, are used to designing with color in mind, collecting numerous swatches from numerous suppliers, and then creating a few samples with different materials. Although many next-gen material companies continue to expand their color offerings, they will likely only have a few colors available for their materials. We anticipate that color offerings of next-gen materials will increase significantly, but brands should be prepared for limited color choices. It may also be difficult to get swatches from early stage next-gen companies, and there may be a limited supply of sample yardage. Brands are advised to allow more time for delivery of swatches and sample yardage.

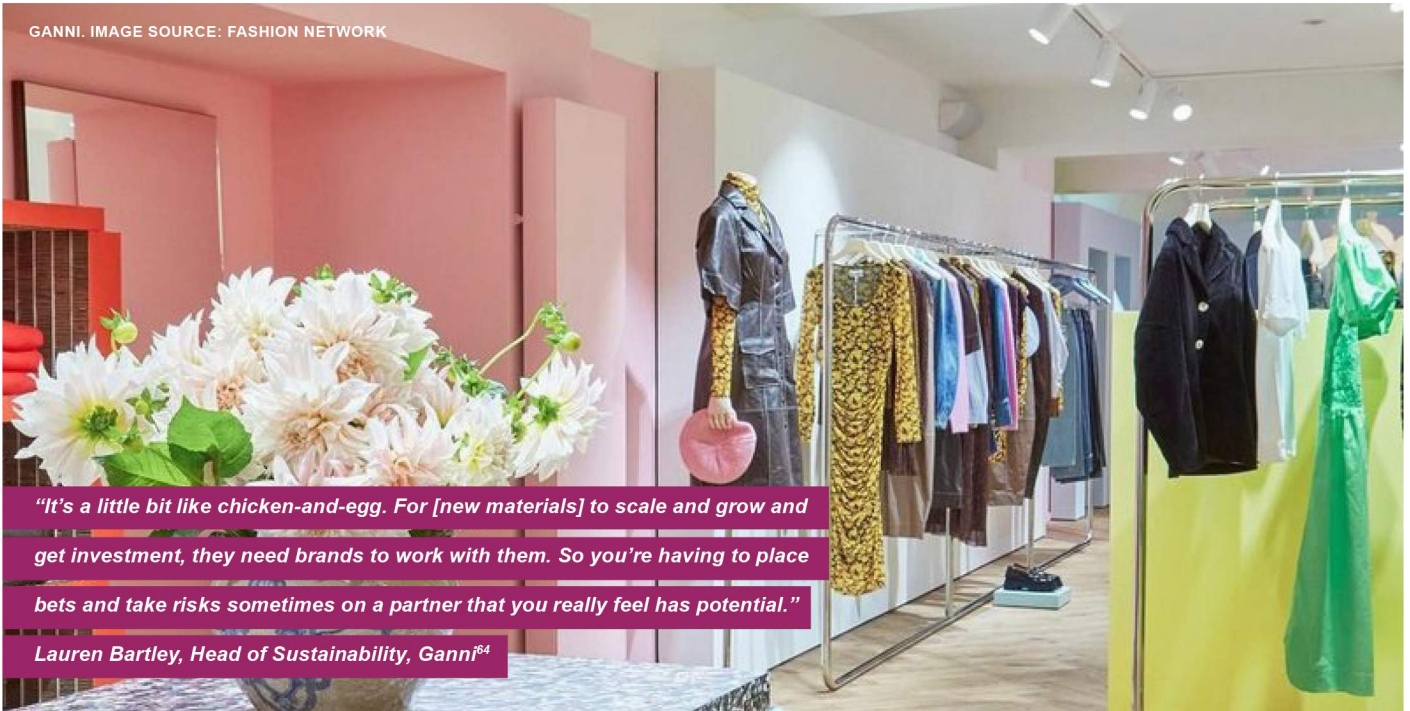
6.

Supply is still limited.

Many brands are starting with capsule collections because of the limited supply. It takes time for a material company to scale to commercial sized production. With such high demand, we expect successful material companies to build multiple production facilities as they grow. Since the volume of next-gen materials is low and there is significant demand, you will likely have to start with a smaller project.

Sourcing materials from a nascent industry takes patience and flexibility. Early mover brands will gain advantages through more consumer interest and trust, a greater understanding of materials' potential, quicker integration of new materials into supply chains, and deeper relationships with material companies giving greater access. We have no doubt that next-gen materials will take over the market. Life on our planet depends on us making more sustainable choices. The Material Innovation Initiative is here to help. Please reach out to us for more information: info@materialinnovation.org.

GANNI. IMAGE SOURCE: FASHION NETWORK



"It's a little bit like chicken-and-egg. For [new materials] to scale and grow and get investment, they need brands to work with them. So you're having to place bets and take risks sometimes on a partner that you really feel has potential."

Lauren Bartley, Head of Sustainability, Ganni⁸⁴

Conclusion

Reasons to use next-gen materials are pressing and important. We must take our environmental impact seriously and we cannot continue to look past animal suffering. Until recently, it has been difficult for brands and consumers to make sustainable choices in replacing animal-based products. With so many next-gen material options now coming to market with increased supply, higher quality, and lower prices, this choice is becoming easier and easier. Ultimately, brands will no longer have an excuse and consumers will hold them accountable.

Many top brands have partnered with material innovators to source and apply next-gen materials in their designs. Transitioning to next-gen materials can play an important role in achieving the sustainability goals that many brands have set for the next few years. Using next-gen materials can ensure that a brand is ahead of the accelerating shift in consumer preference and market trend.

Some brands have opted for developing their own next-gen materials, either to use the materials exclusively for their own label, or to supply to other brands. Some brands have invested in material innovation companies; some have been providing advisory services to material innovators and keeping their hand on the pulse of this rapidly growing and changing next-gen materials industry.

In this report, we have featured over 150 examples of how brands are using next-gen materials. For a snapshot of early movers, see this [list](#).

We hope this report has inspired you to investigate next-gen materials further. Please reach out to us at info@materialinnovation.org to navigate this new and expanding industry.



VON HOLZHAUSEN

References

- ¹ For our analysis of the next-gen materials industry, please see our State of the Industry: *Next-Gen Materials*, July 2021, available at <https://www.materialinnovation.org/state-of-the-industry>
- ² Keri Szejda and Tessa Urbanovich, Alternatives to Leather: An Exploratory Study of U.S. Consumer Perceptions, Conducted by North Mountain Consulting Group for Material Innovation Initiative (Mar 2021). <https://www.materialinnovation.org/consumer-research-1>
- ³ Purchase motivations are typically studied through online consumer surveys, which are best suited for understanding attitudes rather than perfecting predicting behavior. However, in conjunction with a host of other factors, such as normative beliefs, perceived self-efficacy, and environmental determinants, attitudes are considered important components amid the multitude of variables that influence behavior. When consumers are under constraints (e.g., time, sensory, and cost), purchases are often less aspirational. Thus, we expect the attitudinal and purchase intention measures included in the following studies to point toward trends, rather than reflect exact future behavior.
- ⁴ Keri Szejda and Tessa Urbanovich, Consumer Adoption of Next-Gen Materials: A U.S. Segmentation Study, Conducted by North Mountain Consulting Group for Material Innovation Initiative (Sep 2021). <https://www.materialinnovation.org/consumer-research-1>
- ⁵ Keri Szejda and Tessa Urbanovich, Consumer Adoption of Next-Gen Materials: A U.S. Segmentation Study, Conducted by North Mountain Consulting Group for Material Innovation Initiative (Sep 2021). <https://www.materialinnovation.org/consumer-research-1>
- ⁶ Porter Novelli/Cone, Undivided: 2019 Gen Z Purpose Study (2019). <https://www.conecomm.com/research-blog/cone-gen-z-purpose-study>
- ⁷ Lenzing Group, Global Consumer Perception Survey on Sustainable Raw Materials in Fashion and Home Textiles (Feb 2020). <https://www.tencel.com/news-and-events/lenzing-survey-shows-that-transparency-is-key-for-clothing-and-home-textiles-brands-to-win-consumer-trust-and-confidence-with-eco-friendly-and-biodegradable-being-favorable-terms-that-increase-likelihood-of-purchase>.
- ⁸ Keri Szejda and Tessa Urbanovich, Consumer Adoption of Next-Gen Materials: A U.S. Segmentation Study, Conducted by North Mountain Consulting Group for Material Innovation Initiative (Sep 2021). <https://www.materialinnovation.org/consumer-research-1>
- ⁹ Keri Szejda, Yanquin Liu, and Tessa Urbanovich, Next-Gen Leather: Chinese Consumer Perceptions, Conducted by North Mountain Consulting Group for Material Innovation Initiative (Aug 2021). <https://www.materialinnovation.org/consumer-research-1>
- ¹⁰ Business of Fashion and McKinsey & Company, The State of Fashion 2022 (Dec 2021): 1-144. <https://www.mckinsey.com/industries/retail/our-insights/state-of-fashion>
- ¹¹ Bella Webb, "Unpacking Nike's Sustainable Basketball Capsule," VogueBusiness.com, Feb 3, 2021. https://www.voguebusiness.com/sustainability/unpacking-nikes-sustainable-basketball-capsule?utm_source=Vogue+Business+Sustainability&utm_campaign=4575fff59a-EMAIL_CAMPAIGN_2021_04_02_12_22&utm_medium=email&utm_term=0_d562b17dc2-4575fff59a-57999079. Nike, "Sustainable Materials and Innovation," Nike.com, accessed Dec 10, 2021. <https://www.nike.com/sustainability/materials>
- ¹² Global Fashion Agenda and The Boston Consulting Group, Pulse of the Fashion Industry 2018 (May 2018): 18. <https://globalfashionagenda.com/pulse-of-the-fashion-industry-2018-report-released/>
- ¹³ GRACE Communications Foundation, "The Hidden Water in Everyday Products," watercalculator.org, Jul 2, 2017. <https://www.watercalculator.org/footprint/the-hidden-water-in-everyday-products/>
- ¹⁴ Sustainable Apparel Coalition, Higg Index, <https://portal.higg.org/>
- ¹⁵ Stand.earth Research Group, "Nowhere to Hide: How the Fashion Industry is Linked to Amazon Rainforest Destruction," Stand.earth, Nov 29, 2021. <https://www.stand.earth/publication/forest-conservation/amazon-forest-protection/amazon-leather-supply-chain#slidedeck>
- ¹⁶ Paul J. Crutzen, Ingo Aselmann & Wolfgang Seiler, "Methane production by domestic animals, wild ruminants, other herbivorous fauna, and humans," Tellus B: Chemical and Physical Meteorology, 38:3-4 (1986): 271-284. <https://www.tandfonline.com/doi/pdf/10.3402/tellusb.v38i3-4.15135>; UN Environment Programme, "Methane emissions are driving climate change. Here's how to reduce them," unep.org, Aug 20, 2021. <https://www.unep.org/news-and-stories/story/methane-emissions-are-driving-climate-change-heres-how-reduce-them>
- ¹⁷ United States Environmental Protection Agency, "Importance of Methane," epa.gov, accessed Dec 9, 2021. <https://www.epa.gov/gmi/importance-methane>
- ¹⁸ Manuela Andreoni, Hiroko Tabuchi, and Albert Sun, "How Americans' Appetite for Leather in Luxury SUVs Worsens Amazon Deforestation,"

NYTimes.com, Nov 17, 2021. <https://www.nytimes.com/2021/11/17/climate/leather-seats-cars-rainforest.html>

¹⁹ Laura Pitcher, "New study links major fashion brands to Amazon deforestation," TheGuardian.com, Nov 29, 2021. <https://www.theguardian.com/us-news/2021/nov/29/fashion-industry-amazon-rainforest-deforestation> referencing WWF, "Unsustainable Cattle Ranching," WWF.Panda.org, accessed Dec 15, 2021. https://wwf.panda.org/discover/knowledge_hub/where_we_work/amazon/amazon_threats/unsustainable_cattle_ranching/

²⁰ Stand.earth Research Group, "Nowhere to Hide: How the Fashion Industry is Linked to Amazon Rainforest Destruction," Stand.earth, Nov 29, 2021. <https://www.stand.earth/publication/forest-conservation/amazon-forest-protection/amazon-leather-supply-chain#slidedec>

²¹ Laura Pitcher, "New study links major fashion brands to Amazon deforestation," TheGuardian.com, Nov 29, 2021. <https://www.theguardian.com/us-news/2021/nov/29/fashion-industry-amazon-rainforest-deforestation>

²² Manuela Andreoni, Hiroko Tabuchi, and Albert Sun, "How Americans' Appetite for Leather in Luxury SUVs Worsens Amazon Deforestation," NYTimes.com, Nov 17, 2021. <https://www.nytimes.com/2021/11/17/climate/leather-seats-cars-rainforest.html>

²³ To solve some of these problems, the Material Innovation Initiative, with funding from the Laudes Foundation, has hired an environmental data scientist to gather and analyze additional data so that next-gen materials can be compared directly to animal-based materials and synthetics. MII is also establishing a consortium of fashion, home goods, and automotive brands, next-gen material companies, scientists, and nonprofits to advise on procedures for gathering data and conducting analyses.

²⁴ It is important to note that next-gen materials are produced by a variety of technologies across more than 100 companies. Every company has its own proprietary technology and production process and thus the environmental impacts from each material will vary.

²⁵ Note that Higg data does not take into account end-of-life impact which is critical for understanding the entire environmental impact of a material. The methodology for the LCA data in Higg may also vary, meaning that the comparisons are not entirely reliable, or that comparisons are difficult to assess across different types of materials. Some of the data may also be outdated or geographically dependent. Higg offers the best data currently available, however.

²⁶ Adriano Di Marti, Desserto, "Early Life Cycle Assessment," Desserto.com, accessed Dec 13, 2021. <https://desserto.com.mx/e-lca>

²⁷ Sandra Halliday, "Allbirds launches plastic-free Plant Leather with Natural Fiber Welding investment," FashionNetwork.com, Feb 26, 2021. <https://www.fashionnetwork.com/news/Allbirds-launches-plastic-free-plant-leather-with-natural-fiber-welding-investment.1283044.html>

²⁸ Sandra Halliday, "Allbirds launches plastic-free Plant Leather with Natural Fiber Welding investment," FashionNetwork.com, Feb 26, 2021. <https://www.fashionnetwork.com/news/Allbirds-launches-plastic-free-plant-leather-with-natural-fiber-welding-investment.1283044.html>

²⁹ Orange Fiber, "Impact: Sustainability is Key," OrangeFiber.it, accessed Dec 9, 2021. <https://orangefiber.it/impact/>

³⁰ Multiple Authors, "Special section: Our Plastics Dilemma," Science Magazine 373, 6550: 34-69, ScienceMagazineDigital.org, Jul 2, 2021. https://www.sciencemaginedigital.org/sciencemagazine/02_july_2021/MobilePagedReplica.action?u1=41674394&utm_source=newsletter&utm_medium=email&utm_campaign=TXSCI2210701002&utm_content=gtxcel&pm=2&folio=34#pg34

³¹ International Wool Textile Organization (IWTO), IWTO Specifications for Wool Sheep Welfare (April 2020). <https://iwto.org/wp-content/uploads/2020/05/IWTO-Wool-Sheep-Welfare.pdf>

³² Available from: <https://textileexchange.org/resources/>

³³ Available from: https://vendorportal.kering.com/attach/animal_welfare_standards/Kering-Animal-Welfare-Standards-en.pdf

³⁴ Rosemary Feitelberg, "PVH Corp. Said to Agree to Stop Using Exotic Skins, After Appeals by PETA," WWD.com, Sep 10, 2020. <https://www.wwd.com/fashion-news/fashion-scoops/pvh-corp-said-to-agree-to-stop-using-exotic-skins-after-appeals-by-peta-1234579009/>

³⁵ LVMH, "LVMH launches the very first standard for responsible crocodilian leather sourcing and rolls it out in three pilot farms," LVMH.com, Feb 18, 2019. <https://www.lvmh.com/news-documents/press-releases/lvmh-launches-first-standard-responsible-crocodilian-leather-sourcing-three-pilot-farms/>

³⁶ Graham Readfearn, "Australian farm to hold 50,000 crocodiles for luxury Hermès goods questioned by animal welfare groups," TheGuardian.com, Nov 14, 2020. <https://www.theguardian.com/environment/2020/nov/15/australian-farm-to-hold-50000-crocodiles-for-luxury-hermes-goods-questioned-by-animal-welfare-groups>

³⁷ Marie-louise Gumuchian, "ELLE magazine bans fur in all its titles to support animal welfare," Reuters.com, Dec 3, 2021. <https://www.reuters.com/business/sustainable-business/elle-magazine-bans-fur-all-its-titles-support-animal-welfare-2021-12-02/>

³⁸ Jasmin Malik Chua, "Are Exotic Skins Out of Fashion?" NYTimes.com, Sep 21, 2020. <https://www.nytimes.com/2020/09/21/style/exotic->

[skins-fashion-covid.html](#)

³⁹ Fur Free Alliance, "Fur Farming Bans," FurFreeAlliance. com, accessed Dec 13, 2021. <https://www.furfreealliance.com/fur-bans/>

⁴⁰ Ranny Rustam, et. al., Animal Welfare in Fashion: Towards a truly ethical and transparent fashion industry, Four Paws and Good on You, (Dec 2021): 5. <https://wearitkind.four-paws.org.au/blog-news/animal-welfare-in-fashion-report-names-the-best-and-worst-brands-in-2021>

⁴¹ We encourage anyone interested in learning more about animal cruelty in the fashion industry to google "undercover investigation" and then the name of the material plus farm, such as "fur farm" or "wool farm." Below is a sampling of investigations uncovering animal cruelty: The New York Times, "How PETA Won Its Messy Fight and Took a Seat at the Table," May 2020, available at <https://www.nytimes.com/2020/05/31/style/peta-fashion.html>; HSUS, "New undercover investigation shows the cruelty of 'certified' fur farms," Nov 2021, available at <https://blog.humanesociety.org/2021/11/new-undercover-investigation-certified-fur-farms-finland.html>; PETA Asia, "Cows Still Kicking While Slaughtered for Meat and Leather," November 2021, available at <https://fb.watch/9SnFwrOODC/>; PETA, "Crying, Vomiting Alpacas Tied Down, Cut Up for Sweaters and Scarves," available at <https://investigations.peta.org/alpaca-wool-abuse/>; PETA, "14 PETA Wool Industry Exposes on 117 Farms in Six Countries," available at <https://investigations.peta.org/victoria-australia-wool-expose/>; The Guardian, "Secret Videos Reveal Workers Beating Sheep on English and Scottish Farms," available at <https://www.theguardian.com/environment/2018/nov/16/secret-videos-reveal-workers-beating-sheep-on-english-and-scottish-farms>; HSUS, "EXPOSED: Undercover investigation at fur farm shows the lives behind the label," August 2020 available at <https://www.humanesociety.org/news/exposed-undercover-investigation-fur-farm-shows-lives-behind-label>; PETA, "Geese Crushed, Suffocated at Former Canada Goose Down Supplier, available at <https://www.nytimes.com/2020/05/31/style/peta-fashion.html>; "Canada Goose under fire over geese treatment in PETA video," available at <https://www.youtube.com/watch?v=PEKrECn1-vA>. Additional investigations can be found here: <https://animalequality.org/investigations/>, <https://mercyforanimals.org/investigations/>, <https://www.peta.org/investigations/>, <https://www.humanesociety.org/resources/investigations-reports>, <https://animaloutlook.org/investigations/>, <https://sentientworld.org/investigations/>

⁴² HSUS, "New undercover investigation shows the cruelty of 'certified' fur farms," Nov 2021, available at <https://blog.humanesociety.org/2021/11/new-undercover-investigation-certified-fur-farms-finland.html>

⁴³ Manuela Andreoni, Hiroko Tabuchi, and Albert Sun, "How Americans' Appetite for Leather in Luxury SUVs Worsens Amazon Deforestation," NYTimes.com, Nov 17, 2021. <https://www.nytimes.com/2021/11/17/climate/leather-seats-cars-rainforest.html>

⁴⁴ Lyst Insights and Good On You, "The 2020 Conscious Fashion Report," Lyst.com, accessed Dec 15, 2021. <https://www.lyst.com/data/2020-conscious-fashion-report/>

⁴⁵ Lyst Insights and Good On You, "The 2020 Conscious Fashion Report," Lyst.com, accessed Dec 15, 2021. <https://www.lyst.com/data/2020-conscious-fashion-report/>

⁴⁶ REACH stands for the Registration, Evaluation, Authorisation, and Restriction of Chemicals regulation established by the European Union. <https://echa.europa.eu/regulations/reach/understanding-reach>

⁴⁷ Miles Socha, "Karl Lagerfeld Extends Eco Collaboration With Amber Valletta," WWD.com, Apr 8, 2021. <https://wwd.com/fashion-news/designer-luxury/karl-lagerfeld-amber-valletta-collaboration-eco-1234794513/>

⁴⁸ Fashion United Press Club, "Stella McCartney Frayme is the world's first mushroom leather bag featured in a runway show," FashionUnited. uk, Oct 6, 2021. <https://fashionunited.uk/press/fashion/stella-mccartney-frayme-is-the-world-s-first-mushroom-leather-bag-featured-in-a-runway-show/2021100658199>

⁴⁹ Emily Farra, "Stella McCartney Introduces Her First Garments Made Of Mylo, The "Leather" Alternative Grown From Mushrooms," Vogue. co.uk, Mar 18, 2021. <https://www.vogue.co.uk/fashion/article/stella-mccartney-first-mylo-mushroom-leather-alternative-ready-to-wear>

⁵⁰ Joelle Diderich, "Louis Vuitton Spotlights Eco-Design Thrust With Unisex Sneaker," wwd.com, Jul 22, 2021. <https://wwd.com/fashion-news/designer-luxury/louis-vuitton-spotlights-eco-design-thrust-with-unisex-sneaker-1234885897/>

⁵¹ Maxwell Rabb, "Louis Vuitton Releases Luxury Snaker Made From Corn," TheBeet.com, Nov 16, 2021. <https://thebeet.com/louis-vuitton-releases-luxury-sneaker-made-from-corn/>

⁵² Asahi Kasei Europe, "Interior to become the new exterior: New survey by Asahi Kasei Europe shows increasing need towards functional premium surfaces in the automotive," asahi-kasei.eu, Jun 3, 2020. <https://asahi-kasei.eu/interior-to-become-the-new-exterior-new-survey-by-asahi-kasei-europe-shows-increasing-need-towards-functional-premium-surfaces-in-the-automotive/>

⁵³ Yong-woo Lee, Silk Reeling and Testing Manual (Rome: FAO, 1999), chap. 9 "Reeling water." <http://www.fao.org/3/x2099e/x2099e00.htm>

⁵⁴ Vijaykumar P. Kathari et al., "An Energy Efficient Re-Reeling Process for Silk Reeling Industry to Reduce Deforestation," Indian Journal of Fibre & Textile Research 36 (2011): 96-98.

⁵⁵ Fur Free Alliance, "Fur Bans," FurFreeAlliance.com, accessed Dec 15, 2021. <https://www.furfreealliance.com/fur-bans/>

-
- ⁵⁶ Jessica Davis, "Vintage, faux and real: navigating fur in fashion in an age of sustainability," HarpersBazaar.com, Oct 24, 2019. <https://www.harpersbazaar.com/uk/fashion/fashion-news/a29086833/is-faux-fur-sustainable/>
- ⁵⁷ Kaley Roshitsh, "Why Allbirds Is Investing \$2 Million in Natural Fiber Welding," wwd.com, Feb 25, 2021. <https://wwd.com/sustainability/materials/allbirds-investment-plant-leather-bio-based-1234748981/>
- ⁵⁸ Capri Holdings Limited, Corporate Social Responsibility: 2021 Annual Update, Dec 15, 2021. http://s22.q4cdn.com/557169922/files/doc_downloads/2021/12/Capri-Holdings-Limited_CSR-2021-Annual-Update-Report_12.15.21.pdf
- ⁵⁹ Glenn Taylor, "Why Adidas is Investing in This Sustainable Fiber Innovator's IPO," SourcingJournal.com, Jun 10, 2021. <https://sourcingjournal.com/topics/raw-materials/adidas-spinnova-ipo-investment-sustainable-textile-fiber-wood-waste-suzano-284703/>
- ⁶⁰ Spinnova, "Spinnova Plc's ten largest registered shareholders after the completion of the Initial Public Offering and changes in significant holdings," News.Cision.com, Jun 29, 2021. <https://news.cision.com/spinnova/r/spinnova-plc-s-ten-largest-registered-shareholders-after-the-completion-of-the-initial-public-offer,c3375913>
- ⁶¹ Phil Dilanni and Will DeGirolamo, "BMW i Ventures Invests in Natural Fiber Welding, a Company Revolutionizing the Materials Industry Through the Use of All-Natural and Fully Recyclable Ingredients, Closer Cooperation with BMW Group Underway," BMWUSANews.com, Jul 13, 2021. <https://www.bmwusanews.com/newsrelease.do?id=3811&mid=>
- ⁶² See our list here <https://www.materialinnovation.org/current-innovator-profiles>
- ⁶³ Jessica Kruger, "In Search of the Holy Grail: Plastic-free Vegan 'Leather'," LUXTRALondon.com, accessed Dec 19, 2021. <https://luxtralondon.com/blogs/journal/holy-grail>
- ⁶⁴ Rachel Deeley, "How Ganni Plans to Eliminate Leather," BusinessoffFashion.com, Dec 2, 2021. <https://www.businessoffashion.com/articles/sustainability/how-ganni-plans-to-eliminate-leather/>

Acknowledgements

Principal Authors

Elaine Siu, MII Chief Innovation Officer
Fernanda Onça, MII Research Coordinator
Nicole Rawling, MII Chief Executive Officer

Contributors

Thomasine Dolan, MII Fashion Design Specialist
Sydney Gladman, Ph.D., MII Chief Scientific Officer
Jacqueline Kravette, MII Board Member
Brooke Green, Marist College Fashion Student

Editor

Anne Green, MII Project Manager

Graphic Design

Beatriz Calvo Garro

Material Innovation Initiative

The Material Innovation Initiative is a global nonprofit that is striking at the roots of the material industry's sustainability problem by accelerating the development of sustainable next-gen materials for the fashion, automotive, and home goods industries, with a focus on replacing animal-based materials. We believe that technological innovation and untapped natural materials can solve the enormous challenges facing the materials industry.

MIl partners with scientists, startups, brands, and retailers to bring high-performance, eco-friendly, and animal-free materials to market. We also work to shrink the environmental footprint of existing fibers and improve the circularity of commonly used alternatives to animal materials. Our main focus is the global development of new material technologies which produce markedly less environmental destruction, such as precision fermentation, cell cultivation, microbial cultivation, and mycelial growth. The possible applications of these technologies are widespread, with the potential to replace or improve all materials currently used in fashion.

Contact us

info@materialinnovation.org

www.materialinnovation.org

Powered by philanthropy,

MII is a nonprofit 501(c)(3) organization, Tax ID 84-3847333.

© 2022 Material Innovation Institute. All rights reserved.

Permission is granted, free of charge, to use this work for educational purposes.