MATERIAL INNOVATION INITIATIVE

# 2021 STATE OF THE INDUSTRY REPORT: NEXT-GEN MATERIALS

**Cover image credit: SYLVEN NEW YORK**

# EXECUTIVE SUMMARY

The Material Innovation Initiative (MII) is thrilled to offer this report on the state of the next-gen materials industry as of the end of 2021.

In this report, you will find research, analysis, and insights to guide your understanding of this nascent industry. Whether your interest is as an investor or entrepreneur, or as a member of a startup or brand, we have prepared this document to give you the most actionable information about the shift away from animal-based materials that is beginning to ripple through the fashion, automotive, and home goods industries.

Part A includes the **Introduction** and **Definition and Scope** that explains some key concepts and categorizations relevant to the next-gen materials industry.

In Part B, we introduce the three categories of key stakeholders in this industry, or the **3 i's: Innovators, Investors, and Industry Brands**. Innovators are companies, including startups, that create innovative next-gen materials. Investors provide the necessary funding for Innovators' R&D activities and business growth. Industry Brands are the established companies that are the biggest buyers and users of materials, such as adidas, IKEA, and Bentley. Industry Brands play multiple important roles in the ecosystem, including funding both internal and external innovation initiatives, switching to next-gen materials as their raw materials, and collaborating with next-gen material startups to create new products. All this leads to acceleration of commercialization and scale-up production of next-gen materials to replace their conventional counterparts.

In each section of the 3 i's, we present data and statistics to give you an overview of the current state. We then dive into **Case Studies** to illustrate the broader picture: What are the main trends, risks and opportunities? Who's doing what? Who might emerge as the winner?

Part C explores the driving forces accelerating the growth of the next-gen material industry, specifically: white spaces opportunities, changing consumer preferences, and regulatory trends.

**The next-gen material industry is both rapidly emerging and changing. If you find something that should be in our next report, please let us know via this form.**

SYLVEN NEW YORK

The Material Innovation Initiative (MII) is a nonprofit that accelerates the development of high performance, animal-free, and more sustainable materials for the fashion, automotive, and home goods industries. MII partners with startups, investors, brands, and scientists to bring these next-gen materials to market. Visit materialInnovation.org for more details.

# STATE OF THE NEXT-GEN MATERIAL INDUSTRY AT A GLANCE

**95** TOTAL NUMER OF NEXT-GEN MATERIAL COMPANIES

**67** LEATHER

**12** SILK

**7** WOOL

**6** DOWN

**7** FUR

**1** EXOTIC SKINS

**55**

NEW COMPANIES FORMED SINCE 2014

**$2.3 BILLION**

INVESTED SINCE 2015

**$980 MILLION**

RAISED IN 2021 (DOUBLE WHAT WAS RAISED IN 2020)

**$253 MILLION**

LARGEST FUNDING ROUND 2021

**187** UNIQUE INVESTORS

**$863.6 MILLION**

TOTAL AMOUNT RAISED BY THE TOP FUNDED COMPANY

**106** DEALS

SINCE 2015

**49** PLANT-DERIVED

**21** MICROBE-DERIVED

**8** MYCELIUM

**9** BLENDS

**6** RECYCLED MATERIAL

**4** CULTIVATED ANIMAL CELLS

**38 OUT OF 40**

LEADING FASHION BRANDS ACTIVELY SEARCHING FOR NEXT-GEN MATERIALS

Source: Material Innovation Initiative. All data as of Dec 31, 2021.
*Note: Some companies create more than one next-gen material.
**Note: 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%)

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**Look for the IN logo throughout this report for next-gen material industry insights.**

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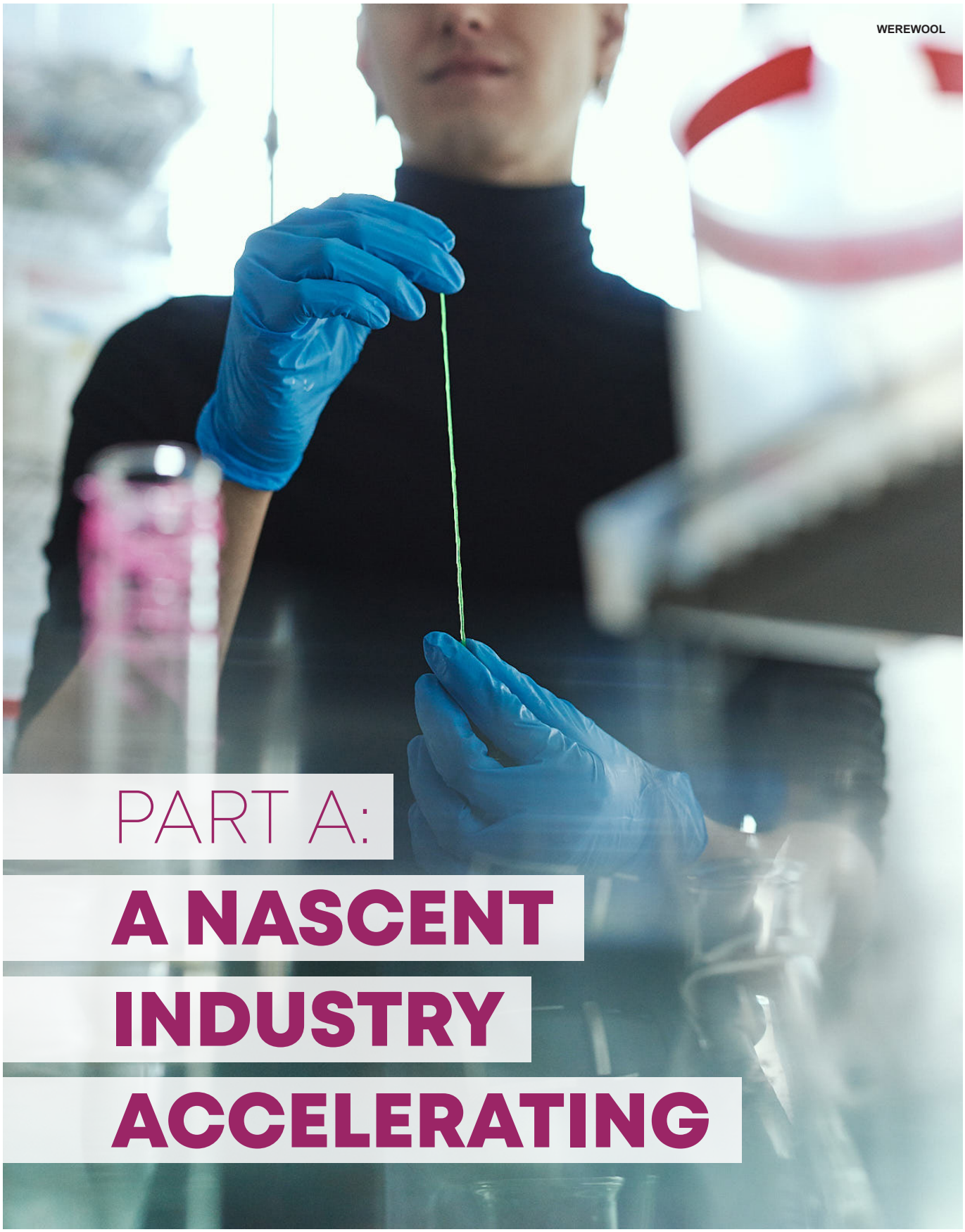



# PART A:

# A NASCENT INDUSTRY ACCELERATING

# 1. INTRODUCTION

Welcome to the nascent industry of next-gen materials, a term MII coined based on our nomenclature assessment study[1] to describe high performance, more sustainable alternatives to animal-derived materials (see section 2 for full definition.)

Conventional livestock-derived materials such as leather, fur, silk, wool, down, and exotic skins, are widely used in the fashion, home goods, and automobile industries. Industrial animal farming is a leading cause of many of the pressing problems of our time, including climate change, environmental degradation, public health risks, and animal cruelty. It is a common misconception that animal-based materials are simply byproducts from industrial animal agriculture that primarily supplies to the food industry. Leather, for example, is the second most profitable product of a cow[2]; and for fur, silk, and exotic skins, the animal material itself is the most profitable product.

## Projection of Growth

In recent years, alternative proteins have disrupted the food industry and continued to accelerate in sales and market share growth, technological advancement, and investments globally. Next-gen materials have emerged as the next big wave in this paradigm shift away from a reliance on industrial animal agriculture, and there are many parallels between the development of the two industries. In fact there are single companies innovating in both areas, though the dynamics of the food industry vary from those of the fashion automotive, and home goods industries which the next-gen materials industry supplies to.

MII has projected that the global wholesale market size for next-gen materials will be approximately USD2.2 billion by 2026.[3] We see the next-gen materials industry as 5-10 years behind where the alternative protein industry is currently. In 2019, McKinsey & Co. estimated the market base for alternative protein at approximately USD2.2 billion compared with a global meat market of approximately USD1.7 trillion.[4]

Much larger market projections have been made, including that the synthetic leather market size will reach USD78.5 billion by 2025.[5] However, since we believe a paradigm shift will be powered by fundamental reinvention and innovation in **raw materials**, all our analyses are focused on the wholesale market of materials, as opposed to the retail market of end products (e.g., garments in fashion, bedding in home goods, seats in automobiles) which is likely at least several times larger. For example, for the leather sub-category, we analyzed the leather material market, not the leather goods market.

**IN**

***"The most significant quantum leap advancements in technology are enabled by innovations in material science. Material technologies are among the only that can impact all fields, fulfilling basic human needs and improving the quality of life on the planet."***

**Material Impact**
**Venture Capital and Company Builder**

The total addressable wholesale market is a sizable $70 billion. The next-gen material industry is nascent now, but we project it will grow quickly to take up 3% of the $70 billion market by 2026. (See more on our methodology and assumptions behind this market size projection here.)

# Momentum and Trend

In 2021, successful collaborations between next-gen material companies and industry brands have made headlines in fashion news (see more in MII's report Brand Engagement with Next-gen Materials: 2022 Landscape). Given that at least two-thirds of a brand's environmental footprint can be attributed to its choice in raw materials[6], more and more brands are taking an active role in promoting R&D for adaptation of next-gen materials as a necessary step towards attaining their sustainability targets. Brands also need to respond to consumers who have indicated clearly that they are ready to support this positive change. In a study of consumers in the U.S. and China, 55% of the U.S. respondents and 66% of Chinese respondents said they would prefer a leather alternative (see section 7 for more details).

Many material innovation companies, including those featured in our previous State of the Industry Report; Spiber, Pangaia, Natural Fiber Welding, VitroLabs, Bolt Threads, and AMSilk; have become familiar names to those following this emerging space. Although next-gen materials are commonly associated with leather derived from plants as a main input, for example, pineapple (Piñatex® by Ananas Anam), grape (by Vegea), mango (by Fruitleather Rotterdam), and apple (by Frumat), many different technologies and inputs are part of reimagining next-gen materials. Mycelium-based materials have attracted much investor, brand, and media interest in the past few years. Innovators such as Bolt Threads, MycoWorks, and Forager Hides (a division under Ecovative) grow the root-like structure of certain fungi species and transform it into sheets of next-gen leather. Another up-and-coming trend of microbe-derived materials is discussed in the case study in section 3 of this report.

With clear interest from consumers and brands, investors are taking notice of the opportunities for significant financial, environmental, and social return by investing in next-gen material companies. Investors see the massive potential of this space and are eager to invest in startups that can transform the materials industry. In fact, there are currently more interested investors than suitable investment opportunities.

There is significant demand for next-gen materials, but not enough supply to meet the sustainability, performance, aesthetic, volume, and price needs of brands and consumers. The Material Innovation Initiative addresses the urgent need to facilitate collaboration between industry players including entrepreneurs, investors, scientists, material companies, and brands to increase the number of companies in this space and support the existing material companies.

"The opportunities for entrepreneurs, scientists, investors, material companies, and brands in next-gen materials continue to rise. There are significant white space opportunities for new companies, innovations, partnerships, and products in this still nascent industry. This industry has ample opportunities for win-wins: not only for financial return but for animals and the environment." Nicole Rawling, MII's co-founder and CEO.

**IN**

***"Futuristic" circular solutions—the kind built on recycled materials or future recyclability—are getting significant buzz, but they truly are of the future. Right now, there are actually no scalable solutions for turning most of our old clothes into new ones.***

**Maxine Bédat**
**Founder of New Standard Institute**
**and author of "Unraveled:**
**The Life and Death of a Garment"**

# 2. DEFINITION AND SCOPE

**"Next-gen materials"** are livestock-free direct replacements for conventional animal-based leather, silk, fur, down, wool, 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.


**Figure 2.1**
**Incumbents, current-gen, and next-gen materials**

### 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-derivered alternatives to animal-based materials: polyurethane, PVC, polyester, acrylic and more. Unfortnately, 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.

WEREWOOL

IN

***"The term next-gen cues innovation and may better describe a new category that has multiple characteristics (i.e., sustainable, animal-free, and high performance)."***

***North Mountain Consulting Group***

**"Disruptive textile technology"** refers to technologies that are not specific to next-gen materials and therefore beyond the scope of this report. Synthetic materials are prevalent in today's world. Sustainable innovation in synthetics such as bio-based, biodegradable, and recycled polyester or polyurethane, and in sustainable renewable-sourced fibers such as cellulosics and natural fibers, could have a broad impact in the plastics and textiles industries as a whole and, in some cases, in the next-gen materials space. To the extent that these broad players and technologies may become promising feedstocks or resources for next-gen material innovation, MII has created a separate database to provide next-gen material innovators an easy way to find potential collaborators.

**"Innovators, investors, and industry brands"** refers to three groups of key stakeholders in the next-gen materials industry. The scope, definition, limitations, and assumptions underpinning the analysis of each stakeholder group are stated in each corresponding section in this report.

# 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.

### 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

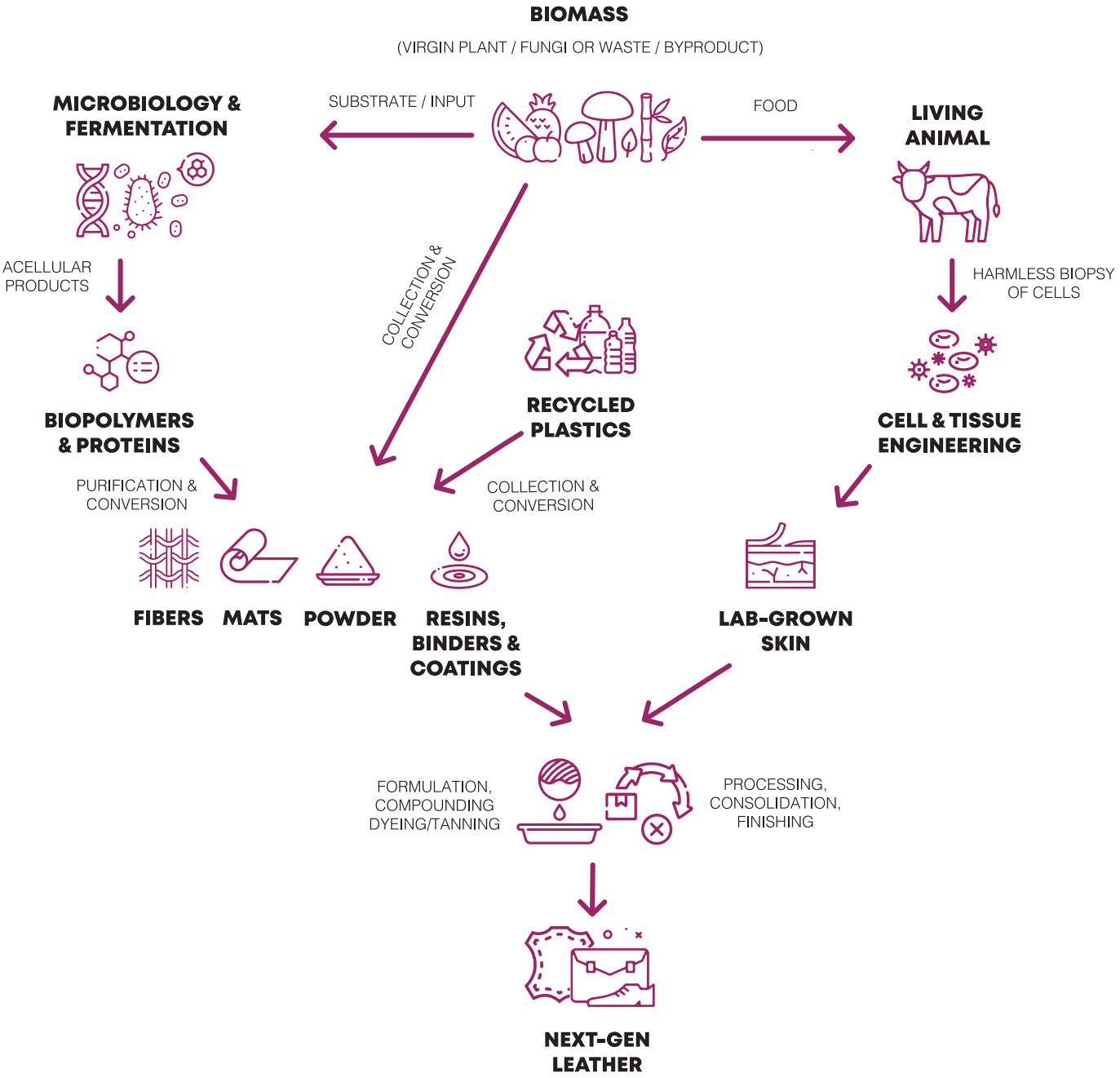
Applies to next-gen materials that utilize recycled plastic or recycled textile feedstock as a main input.

### Blend

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

As an example, Figure 2.2 below illustrates the variety of approaches for producing a next-gen material such as leather.

**Figure 2.2**
**Conceptual landscape of next-gen leather materials**




To learn more about next-gen materials science and engineering, see other MII reports.

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.

KINTRA FIBERS

# PART B: KEY STAKEHOLDERS

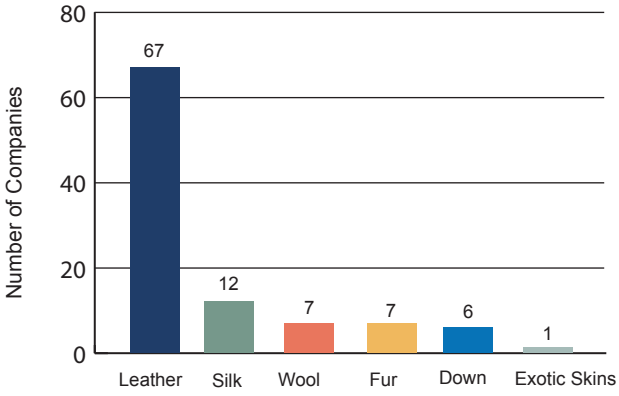
# 3. INNOVATORS

This section provides an overview of companies in the next-gen materials industry.

The list focuses on material innovators and are not exhaustive. Not included are business-to-consumer companies that do not develop and create their own materials, but source instead from a material supplier; R&D happening within corporations that is not publicly disclosed; startups in stealth mode; and any other material innovations that do not fall within the definition of next-gen materials as defined in section 2 (Definition and Scope).

Of the 95 companies, the clear majority (67) work on biomimicry of animal leather. Twelve (12) work on biomimicry of silk, seven (7) on wool, seven (7) on fur, six (6) on down, and one (1) on exotic skins.*

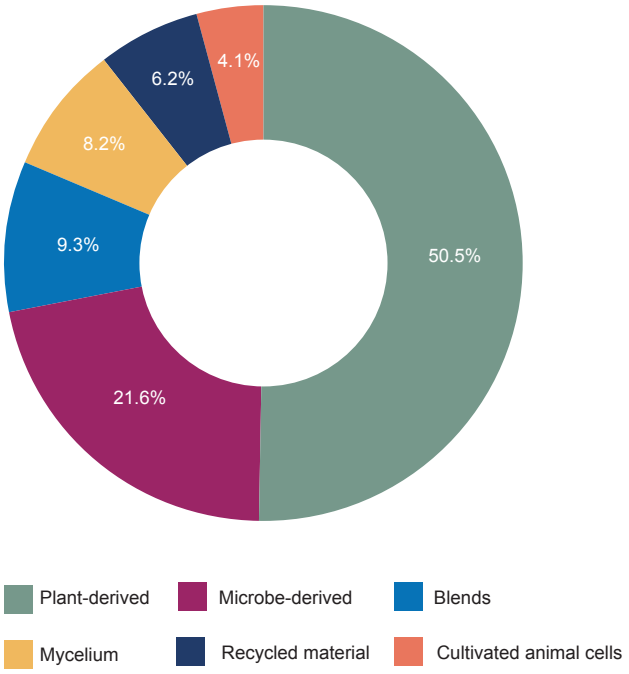
**Figure 3.1**
**Companies working on different next-gen materials**




Although next-gen materials are commonly associated with using plants and plant-derived materials as a main input, many different technologies and inputs are part of reimagining next-gen materials. Of the 95 next-gen material companies listed below, while a majority (49) use plant-derived materials as main input, twenty-one (21) use microbe-derived materials, nine (9) use blends, eight (8) use mycelium, six (6) use recycled material, and four (4) use cultivated animal cells.*

*Some companies work on more than one replacement of animal-based materials. 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 primary application in end products.

**Figure 3.2**
**Next-gen material main inputs**




Material innovators employ a variety of input and technology to create materials that range from mats to fibers to insulating fluff. Some technologies allow a company to achieve diverse biomimicry and applications. In the cases where a company has plans to develop more than one type of next-gen material, the information will only be listed if that material is at least in R&D.

The next-gen materials industry and the Innovators within this ecosystem develop at a fast pace, as can be seen in Figure 3.3 showing the year-on-year number of new companies formed. All company references are purely illustrative. Please check our website (https://www.materialinnovation.org/) for the latest company information.

## Table 3.3
## Next-gen material companies (in alphabetical order)

| Company name | Material name(s) | HQ | Founders | Year founded | Biomimicry | Main input |
|---|---|---|---|---|---|---|
| **Adriano di Marti** | Desserto®, Deserttex® | MEX | Adrián López Velarde, Marte Cázarez | 2019 | Leather | Blend |
| **AlgiKnit** | | USA | Tessa Callaghan, Aleks Gosiewski, Aaron Nesser | 2017 | Silk | Plant-derived |
| **Amadeu** | | BRA | Flavia Amadeu | 2016 | Leather | Plant-derived |
| **AMSilk** | Biosteel® | DEU | Thomas Scheibel | 2008 | Silk | Microbe-derived |
| **Ananas Anam** | Piñatex® | GBR | Carmen Hijosa | 2011 | Leather | Plant-derived |
| **Articor Cork Products** | | ESP | N/A | 1986 | Leather | Plant-derived |
| **Bark Cloth** | Barktex | DEU | Mary Barongo, Oliver Heintz | 1999 | Leather | Plant-derived |
| **Beyond Leather** | Leap™ | DNK | Hannah Michaud, Mikael Eydt | 2016 | Leather | Plant-derived |
| **Bio2Materials** | | POL | Katarzyna Szpicmacher, Aleksandra Kantor, Artur Bartkowiak | 2018 | Leather | Plant-derived |
| **BioFabbrica LLC** (affiliated with Modern Meadow) | Bio-Alloy | USA | Andras Forgacs, Gabor Forgacs, Karoly Jakab, Francoise Marga | 2011 | Leather | Plant-derived |
| **Bioleather** | | IND | Pritesh Mistry | 2019 | Leather | Microbe-derived |
| **Biophilica** | Treekind™ | GBR | Mira Nameth | 2019 | Leather | Plant-derived |
| **Biotecam** | Texticel | BRA | Ricardo Amaral Remer | 2012 | Leather | Microbe-derived |
| **Bolt Threads** | Mylo™, Microsilk™ | USA | Dan Widmaier, David Breslauer, Ethan Mirsky | 2009 | Leather, Silk | Mycelium, Microbe-derived |
| **Bucha Bio** | Shorai™ | USA | Zimri T. Hinshaw, Hoanglong Ly | 2019 | Leather | Microbe-derived |
| **C-Combinator** | | PRI | Geoff Chapin | 2020 | Leather | Plant-derived |
| **Coopflora** | Fabric of the Forest | BRA | 32 member coperative | 2004 | Leather | Plant-derived |
| **Corkor** | | PRT | Natalia Guerreiro, Vitor Lopes | 2012 | Leather | Plant-derived |
| **Coronet** | BioVeg, Maison, Innovaction | ITA | Enrico De Marco | 1966 | Leather | Blend |
| **Culthread** | | GBR | Rina Einy | 2018 | Fur | Recycled material |
| **Devo Home** | | UKR | Oksana Devoe | 2008 | Fur | Plant-derived |
| **Eco Vegan Leather Private Limited** | Ultraw Vegan Leather | IND | N/A | 2021 | Leather | Plant-derived |
| **Ecopel** | KOBA® Faux fur, Cannaba Wool, GACHA-Fur | CHN | Christopher Sarfati | 2003 | Fur | Blend |
| **EcoSimple** | | BRA | Cláudio Rocha, Marisa Ferragutt | 2010 | Wool | Recycled material |
| **EcoSupreme** | | USA | Ivan (Hui) Wang | 2008 | Down | Microbe-derived |
| **Ecovative** | MycoFlex™, Forager™ Hides | USA | Gavin McIntyre, Eben Bayer | 2007 | Leather | Mycelium |
| **ENKA** | | POL | Parent Company: International Chemical Investors Group | 1924 | Silk | Plant-derived |
| **Ettitude** | CleanBamboo™ | USA | Phoebe Yu | 2014 | Silk | Plant-derived |
| **Faborg** | Weganool™ | IND | Shankar Dhakshinamoorthy | 2015 | Wool | Plant-derived |
| **Faircraft** | | FRA | Haïkel Balti, Cesar Valencia Gallardo | 2020 | Leather | Cultivated animal cells |
| **Fiquetex** | | COL | Alejandro Moreno, Gabriel Moreno | 2017 | Leather | Plant-derived |
| **Flocus** | | NLD | Jeroen Muijsers | 2014 | Down | Plant-derived |
| **Flora Fur** | | USA | Isabella Bruski, Noah Silva | 2018 | Fur, Wool | Plant-derived |
| **Fruitleather Rotterdam** | | NLD | Koen Meerkerk, Hugo de Boon | 2016 | Leather | Plant-derived |
| **Frumat** | Appleskin™ | ITA | Hannes Parth | 2008 | Leather | Blend |
| **Furoid** | LIQUIDWOOL™ | NLD | Maria Zakurnaeva, Henri Kunz | 2017 | Fur, Wool | Cultivated animal cells |
| **Grado Zero Innovation** | BioGreen Padding, Muskin™ | ITA | Giada Dammacco, Filippo Pagliai | 2001 | Down, Leather | Plant-derived |
| **Gunas New York** | Mulbtex™ | USA | Sugandh G. Agrawal | 2009 | Leather | Plant-derived |
| **Hemp Black** | HEMP BLACK™/hide | USA | N/A | 2017 | Leather | Blend |
| **House of Fluff** | BIOFUR™ | USA | Kym Canter | 2017 | Fur | Blend |
| **Jacinto & Liro** | | PHL | Anne Mariposa-Yee, Noreen Bautista, Patricia Lalisan, Ryan Pelongco, and Charm Cruz | 2009 | Leather | Plant-derived |
| **KD New York** | Vegetable Cashmere | USA | David Lee, Tricia Kaye | 1980 | Wool | Plant-derived |
| **Kombucha Couture** | | USA | Sacha Laurin | 2013 | Leather | Microbe-derived |
| **Le Qara** | | PER | Jacqueline L. Cruz, Isemar Cruz | 2017 | Leather | Microbe-derived |
| **Luckynelly** | Berriestex, Citrustex | DEU | Christine Rochlitz | 2012 | Leather | Plant-derived |
| **MakeGrowLab** | TransLeather™ | POL | Roza Janusz, Josh Brito | 2016 | Leather | Microbe-derived |
| **Malai** | | IND | Zuzana Gombošová, Susmith C S | 2018 | Leather | Microbe-derived |
| **Miko** | Dinamica® | ITA | N/A | 2015 | Leather | Blend |

| | | | | | | |
|---|---|---|---|---|---|---|
| **MINK** | | USA | Rebecca Mink | 2000 | Leather | Plant-derived |
| **Modern Synthesis** | | GBR | Jen Keane, Ben Reeve | 2020 | Leather | Microbe-derived |
| **Mogu** | | ITA | Maurizio Montalti, Stefano Babbini, Federico Maria Grati | 2015 | Leather | Mycelium |
| **MycaNova (Citrique Belge)** | MycaNova | BEL | N/A | 1929 | Leather | Plant-derived |
| **MYCL - Mycotech Lab** | Mylea™ | IDN | Annisa Wibi, Adi Reza Nugroho, Ronaldiaz Hartantyo, Arekha Bentangan, Robby Zidna Ilman | 2015 | Leather | Mycelium |
| **MycoWorks** | Reishi™ | USA | Philip Ross, Sophia Wang, Eddie Pavlu | 2013 | Leather | Mycelium |
| **Mylium** | | NLD | Iris Houthoff | 2018 | Leather | Mycelium |
| **Natural Fiber Welding** | Mirum® | USA | Luke Haverhals | 2015 | Leather | Plant-derived |
| **Neffa** | MycoTEX® | NLD | Aniela Hoitink | 2016 | Leather | Mycelium |
| **Newlight** | AirCarbon™ | USA | Kenton Kimmel, Mark Herrema | 2003 | Leather | Microbe-derived |
| **Nova Kearu** | beLEAF™ | BRA | Eduardo Filgueiras | 2006 | Leather | Plant-derived |
| **Nova Milan** | | CRI | Irma Orenstein, Karim Quazzani, Dror Weksler, Mycol Benhamou | 2019 | Leather | Plant-derived |
| **Nuvi Nomad** | NUVI Releaf | DEU | Nina Rössler | 2014 | Leather | Plant-derived |
| **Ohoskin** | | ITA | Adriana Santanocito | 2020 | Leather | Plant-derived |
| **Oleago** | Oleatex™ | TUR | Eşref Açık, Recep Eroğlu, Emre Eroğlu | 2021 | Leather | Plant-derived |
| **Ono Collaborations** | | CHE | Bernadette Christina Bodenmueller | 2017 | Leather | Plant-derived |
| **Orange Fiber** | | ITA | Enrica Arena, Adriana Santanocito | 2014 | Silk | Plant-derived |
| **Osom Brand** | Osomtex® | USA | Patricia Ermecheo | 2016 | Wool | Recycled material |
| **Panama Trimmings** | Viridis® | ITA | Giuliano Pinato | 1981 | Leather | Plant-derived |
| **Pangaia** | FLWRDWN™ | GBR | Jasmine Mullers, Rachna Bhasin, Nathalie Longuet | 2018 | Down | Plant-derived |
| **Patent Shoes/Biotech** | BacLEATHER™ | ESP | Concha Garcia, L.A. Fernándes | 2012 | Leather | Microbe-derived |
| **Phool** | Fleather | IND | Ankit Agarwal | 2009 | Leather | Microbe-derived |
| **Polybion** | Celium® | MEX | Axel Gómez-Ortigoza, Alexis Gómez-Ortigoza | 2015 | Leather | Microbe-derived |
| **Provenance Bio** | | USA | Michalyn Andrews, Christian Ewton | 2016 | Leather | Microbe-derived |
| **Proyecto Menos es Más** | Bambuflex© | ARG | Natalia Pérez | 2010 | Leather | Plant-derived |
| **Qorium** | | NLD | Rutger Ploem, Stef Kranendijk, Mark Post | 2015 | Leather | Cultivated animal cells |
| **Renewcell** | Circulose | SWE | Mikael Lindström, Christofer Lindgren, Malcolm Norlin, Gunnar Henriksson | 2012 | Silk | Recycled material |
| **SaltyCo** | BioPuff® | GBR | Julian Ellis-Brown, Antonia Jara-Contreras, Finlay Duncan | 2020 | Down | Plant-derived |
| **Save The Duck** | Plumtech® | CAN | Nicolas Bargi | 2012 | Down | Recycled material |
| **ScobyTec** | ScobyTec BNC | DEU | Carolin Wendel, Bernhard Schipper, Carolin Schulze | 2014 | Leather | Microbe-derived |
| **Seevix Material Sciences** | SVX™ | ISR | Shlomzion Shen, Shmulik Ittah | 2014 | Silk | Microbe-derived |
| **Seringueira** | | BRA | Wilson Antônio Manzoni | 2016 | Leather | Plant-derived |
| **Slow Factory Labs** | Slowhide | USA | Céline Semaan, Colin Vernon | 2021 | Leather | Microbe-derived |
| **SmartFiber AG** | SeaCell™, Smartcel™ | DEU | Subsidiary of Lenzing AG | 2005 | Silk | Plant-derived |
| **Spiber** | Brewed Protein™ | JPN | Kazuhide Sekiyama, Sugawara Junichi | 2007 | Silk | Microbe-derived |
| **Spidey Tek** | | USA | Roberto Velozzi | 2015 | Silk | Plant-derived |
| **Spinnova** | | FIN | Juha Salmela, Janne Poranen | 2014 | Wool | Plant-derived |
| **Spora Biotech** | Sporatex | CHL | Hernán Rebolledo, José Miguel Figueroa | 2017 | Leather | Mycelium |
| **Tenbro** | | CHN | N/A | 2002 | Silk | Plant-derived |
| **The Center for Renewable Materials (UC San Diego)** | | USA | Anastasia Bachykala, Michael Burkart, Luca Bonanomi, Naser Pourahmady | 2020 | Leather | Microbe-derived |
| **Ultrafabrics** | Ultraleather® Volar Bio | USA | Clay Andrew Rosenberg, Barbara Danielle Boecker-Primack | 1966 | Leather | Blend |
| **Unreal Fur** | | AUS | Gilat Shan | 2011 | Fur | Recycled material |
| **Vegea** | | ITA | Francesco Merlino, Gianpiero Tessitore, Valentina Longobardo | 2016 | Leather | Plant-derived |
| **VegSkin** | | FRA | Loïc Debrabander, Anaëlle Picavet | 2020 | Leather | Plant-derived |
| **Vitro Labs** | | USA | Ingvar Helgason | 2016 | Leather, Exotic Skins | Cultivated animal cells |
| **von Holzhausen** | Banbū Leather™, Technik-Leather™ | USA | Vicki von Holzhausen | 2015 | Leather | Plant-derived, Blend |
| **Zvnder** | Fungiskin | DEU | Nina Fabert | 2017 | Leather | Plant-derived |

This list is not exhaustive and only reflects MII's company database as of Dec 31, 2021. Please check our website www.materialinnovation.org for more updated list of companies.

Have we missed anything? Please let us know through this form.

## Table 3.4
## Material manufacturers that have next-gen materials in their offerings

| Company name | Material name | Headquarters | Biomimicry | Main input |
|---|---|---|---|---|
| **3M** | Thinsulate™ Insulation - Featherless | USA | Down | Recycled material |
| **Asahi Kasei Corporation** | Lamous, Bemberg™ | JPN | Leather, Silk | Blend, Plant-derived |
| **Eastman** | Naia™ | USA | Silk | Plant-derived |
| **Fiscatech** | Ultra Wer; Fly Tela Eco, Rinnova, E-ULTRA® | ITA | Leather | Blend; Plant-derived |
| **General Silicones** | Compo-SiL® (Vegan Silicone Leather, launched in 2018) | TWN | Leather | Blend |
| **ISA TanTec** | COSM™ (Creation of Sustainable Materials) - HyphaLite, VeraLite | MAC | Leather | Plant-derived |
| **Jord** | Suberhide™ | USA | Leather | Plant-derived |
| **Kuraray Co. Ltd.** | CLARINO™ Sustainable Collection | JPN | Leather | Blend |
| **Lenzing** | Tencel™, Ecovero™ | AUT | Down, Fur, Wool, Silk | Plant-derived |
| **Polartec** | Power Fill™ | USA | Down | Recycled material |
| **PrimaLoft** | PrimaLoft® Bio™ | USA | Down | Recycled material |
| **Sileather** | N/A | USA | Leather | Blend |
| **The LYCRA Company** | THERMOLITE® EcoMade T-DOWN | USA | Down | Recycled material |
| **Thermore** | Ecodown® | NLD | Down | Recycled material |
| **Toray Industries, Inc.** | Ultrasuede® | JPN | Leather | Blend |
| **Vegatex Biotech** | Vegatex™ | CHN | Leather | Plant-derived |

**IN**

***"In 2022, we're likely to see the development and adoption of next-gen materials accelerate as continued investments and major partnerships set the tone for these technologies to scale and compete with existing materials in terms of performance, price, and aesthetics."***

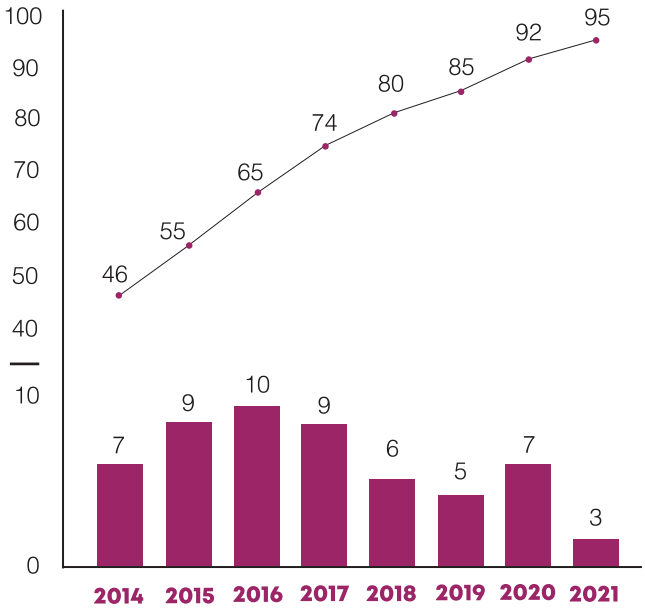
***Sustainable Fashion Forum***

SYLVEN NEW YORK

# Trend

Of the 95 companies innovating in next-gen materials, 55 have been established since 2014. Most (41) of these 55 new companies are working on leather biomimicry. In the same period, five (5) companies were formed that work on biomimicry of silk, five (5) on wool, four (4) on fur, three (3) down, and one (1) on both leather and exotic skins.

**Figure 3.5**
**Number of companies growth trend**




| Year | Leather | Silk | Wool | Fur | Down | Exotic skins |
|---|---|---|---|---|---|---|
| **2014** | 2 | 3 | 1 | - | 1 | - |
| **2015** | 7 | 1 | 1 | - | - | |
| **2016** | 9 | - | 1 | - | - | |
| **2017** | 6 | 1 | 1** | 2 | - | 1* |
| **2018** | 3 | - | 1 | 2*** | 1 | |
| **2019** | 5 | - | - | - | - | |
| **2020** | 6 | - | - | - | 1 | |
| **2021** | 3 | - | - | - | - | |

*VitroLabs creates both leather and exotic skins and is thus counted as “1” under leather and “1” under exotic skin, but is NOT counted twice under “Number of companies formed” and “Total number of companies.

**Furoid creates both fur and wool and is thus counted as “1” under fur and “1” under wool, but is NOT counted twice under “Number of companies formed” and “Total number of companies.”

***Flora Fur creates both fur and wool and is thus counted as “1” under fur and “1” under wool, but is NOT counted twice under “Number of companies formed” and “Total number of companies.”

# Case Study

The following aims to shed light on another up-and-coming trend: microbe-derived materials. These materials use bioreactors full of microorganisms as mini-factories to produce useful precursors for material categories such as next-gen leather or silk. Below we highlight two examples of microbe-derived next-gen innovation.

NEWLIGHT

Newlight is a California-based company founded in 2003. It manufactures a new material called AirCarbon, which is a biosynthetic called polyhydroxybutyrate (PHB) that can be melted and cooled into fibers, sheets, and solid parts and be used to replace materials like petrochemical-derived plastic and animal leather.

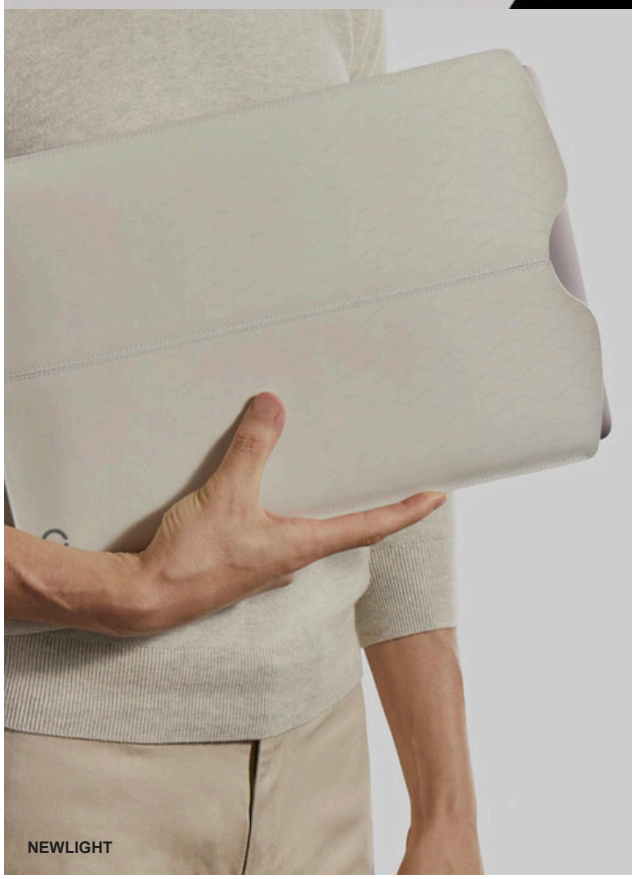
**Tech:**
Ocean microorganisms are placed in a medium to turn methane and carbon dioxide into PHB. Newlight uses an IBM blockchain technology to create an indelible record of each step in the transformation of greenhouse gas to high-performance AirCarbon biomaterials.

**Scale:**
Over 2007 to 2017, Newlight continued to work on its pilot plant to advance in reactor design, biocatalyst design, purification, and material performance. The company announced its fully-integrated commercial-scale production system in 2019. In 2020, Newlight launched Covalent™, a fashion brand that utilizes the natural plastic AirCarbon to make its carbon-negative accessories, including glasses, laptop sleeves, and cardholders.


***"What if we could use the technology in nature to turn greenhouse gas into high-value materials?"***

***Newlight Technologies***


NEWLIGHT


NEWLIGHT

IN

**“There is a rich history in humanity’s use of microbe-derived products, from beer and bread, to insulin for diabetes treatment. We can now harness the power of biotechnology for next-gen materials, creating biological factories that grow specialized bacteria or yeast designed to output the building blocks for material innovations. With a diverse portfolio of microbe-derived products including proteins such as collagen (leather) and silk, fossil-free and biodegradable plastics, and versatile cellulose-based materials, this category takes many approaches to high performance, sustainable material formulations.**

**We find it interesting that over a dozen next-gen leather startups are investigating bacterial cellulose, a material similar to the “skin” formed during kombucha production – these innovators may be brewing up a new material solution. Excitingly, the small footprint needed to make microbe-derived materials means we can make valuable materials while avoiding resource-heavy practices such as factory farming, clearing forests, or extracting fossil fuels.”**

**Dr. Sydney Gladman**
**Chief Science Officer**
**Material Innovation Initiative**

# modern synthesis

Modern Synthesis is a London-based biomaterial start-up developing cellulose-based composites to create solutions for the fashion industry.

**Tech:**
The company's microbial weaving' process uses bacteria to grow a cellulose-based composite material.

**Scale:**
R&D

Modern Synthesis' patent-pending microbial weaving is a biofabrication process which means the material is actually grown, using a microbe. The process includes creating a scaffold using robotic fiber placement, which bacteria then grows material around to create a strong, lightweight biomaterial.[9]

Advantages to this method include[10]:

• Low-cost
• Biodegradable
• Less waste (given the ability to design a piece to shape, without creating unnecessary materials that then get cut out for assembly during the design and manufacture process)
• Strength (nanocellulose produced by bacteria k.rhaeticus, on a fiber level, is up to 8 times stronger than steel and stiffer than kevlar)

Keane had the rare chance to step behind the curtain of Bolt Threads as their first Creative Resident, prior to her founding Modern Synthesis. While Bolt Threads focuses on mycelium, Modern Synthesis set out to grow new materials using bacteria. And as Keane said, it has always been about swapping ideas to explore how to build better systems for biodesign, "competition is out, and collaboration is in".


MODERN SYNTHESIS

***"If you haven't heard, competition is out, and collaboration is in, especially when it comes to sustainability. And in the race to avert climate catastrophe, we need all hands on deck. But innovation is messy, and behind the hype of the emerging biofabrication industry is a lot of trial and error, and failed experiments that go unseen."***

***Jen Keane***
***CEO & Creative Director of Modern Synthesis***


MODERN SYNTHESIS

# 4. INVESTORS

## Overview

This section provides an overview of the investment activities in the next-gen materials industry.

In 2021, we saw the first exit in the nascent next-gen materials industry. Spinnova, the Finnish technology company that uses FSC-certified wood and waste streams to produce next-gen wool, went public in June 2021. The company raised approximately USD135 million in the initial public offering of its shares on Nasdaq First North Growth Market Finland. Notably, adidas Ventures B.V. was one of the cornerstone investors in the IPO. Spinnova only had two publicly disclosed rounds of funding prior to its IPO; the most recent was a venture round raising USD12.3 Million in 2019.

Other investment highlights include:

- Bolt Threads raised a $253 million Series E at a $1.15 billion valuation.
- Ecovative raised a $60 million Series D.
- Natural Fiber Welding has received backing from BMW i Ventures and Allbirds, raising $15 million in addition to doubling its commercial manufacturing footprint.

The data collected and analyses conducted are based solely on MII's company database (list of companies in table 3.1). The list of investors, investment figures, and other data are limited by publicly disclosed information. Since corporate R&D investment and other undisclosed deals are not included, the investment figures presented in this section, whether in relation to the industry or to each individual company or investor, are likely underestimated. Grants and academic funding are also specifically excluded from this overview.

Beyond the information in this section, many investors are evaluating deals, but have not yet completed their first investment in this space. All investment, investor, and company references are purely illustrative. Please note that the figures published in this report may differ from prior figures published by MII as we continually improve our dataset.

IN

***"We estimate that the global wholesale market size for next-gen materials will be approximately $2.2 billion (USD) in 2026, representing a 3% share of an addressable market of over $70 billion."***

***Material Innovation Initiative, State of the Industry Report: Next-Gen Materials 2020***[12]

FORAGER/ECOVATIVE

## Table 4.1
## Investors in next-gen material companies by deal count

The following is a list of investors in the next-gen material companies listed in table 4.1, in descending order by number of investments. Only publicly disclosed information is included.

| Investor | Number of Investments | Number of Companies Invested In | Companies | Investor Type | HQ |
|---|---|---|---|---|---|
| **SOSV** | 7 | 3 | Bucha Bio, MycoWorks, AlgiKnit | Accelerator, Micro VC, Venture Capital | USA |
| **Horizons Ventures** | 6 | 2 | Modern Meadow, AlgiKnit | Venture Capital | CHN |
| **Anthony Fadell** | 3 | 2 | MycoWorks, Modern Meadow | Individual/Angel | FRA |
| **Artis Ventures (AV)** | 3 | 1 | Modern Meadow | Venture Capital | USA |
| **Athos Group** | 3 | 1 | AMSilk | Corporation | USA |
| **Formation 8** | 3 | 1 | Bolt Threads | Venture Capital | USA |
| **Foundation Capital** | 3 | 1 | Bolt Threads | Venture Capital | USA |
| **ICONIQ Capital** | 3 | 1 | Modern Meadow | Private Equity Firm, Venture Capital | USA |
| **IndieBio** | 3 | 2 | MycoWorks, Bucha Bio | Accelerator | USA |
| **MUFG Bank** | 3 | 1 | Spiber | Investment Bank, Venture Capital | JPN |
| **Novo Holdings** | 3 | 2 | AMSilk, MycoWorks | Venture Capital | DEN |
| **RebelBio** | 3 | 1 | AlgiKnit | Venture Capital | GBR |
| **8VC** | 2 | 1 | MycoWorks | Venture Capital | USA |
| **Activate Venture Partners** | 2 | 1 | Modern Meadow | Micro VC | USA |
| **AgFunder** | 2 | 1 | MycoWorks | Venture Capital | USA |
| **Alafi Capital** | 2 | 1 | Bolt Threads | Venture Capital | USA |
| **Archer Daniels Midland Company (ADM)** | 2 | 1 | Spiber | Corporation | USA |
| **Baillie Gifford** | 2 | 2 | Bolt Threads, Spiber | Investment Bank, Venture Capital | GBR |
| **Baleine & Bjorn Capital** | 2 | 1 | VitroLabs | Venture Capital | USA |
| **Breakout Ventures** | 2 | 2 | Modern Meadow, Ecovative | Micro VC | USA |
| **Capital V** | 2 | 2 | Ananas Anam (Piñatex), Natural Fiber Welding | Micro VC | NLD |
| **Collaborative Fund** | 2 | 1 | Modern Meadow | Micro VC | USA |
| **Cool Japan Fund** | 2 | 1 | Spiber | Government Office, Venture Capital | JPN |
| **CPT Capital** | 2 | 2 | VitroLabs, Modern Meadow | Venture Capital | GBR |
| **DCVC Bio** | 2 | 1 | MycoWorks | Venture Capital | USA |
| **East West Capital Limited** | 2 | 1 | Bolt Threads | Venture Capital | AUS |
| **Ethos VC** | 2 | 1 | Natural Fiber Welding | Venture Capital | USA |
| **Fashion For Good** | 2 | 2 | Natural Fiber Welding, AlgiKnit | Accelerator | NLD |
| **Founders Fund** | 2 | 1 | Bolt Threads | Venture Capital | USA |
| **Future Tech Lab** | 2 | 2 | VitroLabs, MycoWorks | Venture Capital | SWE |
| **Gaingels** | 2 | 2 | MycoWorks, VitroLabs | Venture Capital | USA |
| **Gaingels** | 2 | 2 | MycoWorks, VitroLabs | Venture Capital | USA |
| **MIG** | 2 | 1 | AMSilk | Venture Capital | DEU |
| **Mission Bay Capital** | 2 | 1 | Bolt Threads | Venture Capital | USA |
| **Rockstart** | 2 | 1 | Beyond Leather | Accelerator, Venture Capital | NLD |
| **Sequoia Capital** | 2 | 1 | Modern Meadow | Venture Capital | USA |
| **Shonai Bank** | 2 | 1 | Spiber | Investment Bank | JPN |
| **Temasek Holdings** | 2 | 2 | Bolt Threads, Modern Meadow | Private Equity Firm | SGP |
| **The Yamagata Bank** | 2 | 1 | Spiber | Investment Bank | JPN |
| **Wireframe Ventures** | 2 | 1 | MycoWorks | Venture Capital | USA |
| **Zygote Ventures** | 2 | 1 | Bolt Threads | Angel Group | USA |
| **10X Capital** | 1 | 1 | MycoWorks | Venture Capital | USA |
| **37 Angels** | 1 | 1 | ettitude | Angel Group | USA |
| **3M** | 1 | 1 | Ecovative | Corporation | USA |
| **79 Ventures** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **Aaron Mendes** | 1 | 1 | VitroLabs | Individual/Angel | USA |
| **ADB Ventures** | 1 | 1 | Ananas Anam (Piñatex) | Venture Capital | PHL |
| **Advantage Capital** | 1 | 1 | Natural Fiber Welding | Private Equity Firm, Venture Capital | USA |
| **AIM Partners** | 1 | 1 | Ecovative | Private Equity Firm | GBR |
| **Alia Bhatt** | 1 | 1 | Kanpur Flowercycling Private Limited (Phool) | Individual/Angel | IND |

| | | | | | |
|---|---|---|---|---|---|
| **Allbirds** | 1 | 1 | Natural Fiber Welding | Corporation | USA |
| **Allen & Company** | 1 | 1 | Bolt Threads | Family Investment Office, Investment Bank, Venture Capital | USA |
| **Alpha Impact Investment Management Partners** | 1 | 1 | Ecovative | Private Equity Firm, Venture Capital | USA |
| **Andrew Abraham** | 1 | 1 | Ecovative | Individual/Angel | USA |
| **Angels for Women** | 1 | 1 | Orange Fiber | Angel Group | ITA |
| **Antonio Perdichizzi** | 1 | 1 | Orange Fiber | Individual/Angel | ITA |
| **Astanor Ventures** | 1 | 1 | Modern Meadow | Venture Capital | BEL |
| **Beni VC (BVC)** | 1 | 1 | Bucha Bio | Venture Capital | USA |
| **Besodos Investors** | 1 | 1 | Spinnova | Private Equity Firm | FIN |
| **Black Point Group** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **Blue Wire Capital (BWC)** | 1 | 1 | Faircraft | Venture Capital | GBR |
| **BMW i Ventures** | 1 | 1 | Natural Fiber Welding | Corporate Venture Capital | USA |
| **Brightlands Venture Partners** | 1 | 1 | Qorium | Venture Capital | NLD |
| **Buckminster Fuller Institute** | 1 | 1 | Ecovative | - | USA |
| **Business Finland** | 1 | 1 | Spinnova | Government Office, Venture Capital | FIN |
| **Cap-Meridian Ventures** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **Cape Capital** | 1 | 1 | Modern Meadow | Private Equity | CHE |
| **Cargill** | 1 | 1 | AMSilk | Corporation | USA |
| **Cary Pinkowski** | 1 | 1 | Bucha Bio | Individual/Angel | CAN |
| **Central Illinois Angels** | 1 | 1 | Natural Fiber Welding | Angel Group | USA |
| **Chris Smalling** | 1 | 1 | Ananas Anam (Piñatex) | Individual/Angel | GBR |
| **Community Development Venture Capital Alliance** | 1 | 1 | Natural Fiber Welding | Venture Capital | USA |
| **Continental Grain Company** | 1 | 1 | Modern Meadow | Corporate Venture Capital | USA |
| **Courtney Hull** | 1 | 1 | Ecovative | Individual/Angel | USA |
| **Cristina Stenbeck** | 1 | 1 | VitroLabs | Individual/Angel | USA |
| **Cthulhu Ventures** | 1 | 1 | MycoWorks | Micro VC, Venture Capital | USA |
| **Dai-ichi Life** | 1 | 1 | Spiber | Investment Bank, Venture Capital | JPN |
| **DOEN Participaties** | 1 | 1 | Ecovative | Venture Capital | NLD |
| **Drumbeat Ventures** | 1 | 1 | ettitude | Venture Capital | USA |
| **E.R. Capital Holdings** | 1 | 1 | AMSilk | Private Equity | DEU |
| **Ebara Corporation** | 1 | 1 | Spiber | Corporation | JPN |
| **Enmi Kendall** | 1 | 1 | Modern Meadow | Investment Partner, Individual/Angel | USA |
| **Entrepreneur First** | 1 | 1 | Faircraft | Venture Capital | GBR |
| **Entrepreneurs Roundtable Accelerator** | 1 | 1 | ettitude | Venture Capital | USA |
| **Eudaimonia Capital** | 1 | 1 | Modern Meadow | Angel Group, Family Investment Office | SGP |
| **European Investment Bank** | 1 | 1 | Spinnova | Government Office, Investment Bank | LUX |
| **Evolution VC Partners** | 1 | 1 | Natural Fiber Welding | Venture Capital | USA |
| **Evonik Venture Capital** | 1 | 1 | Modern Meadow | Corporate Venture Capital, Venture Capital | DEU |
| **Fibria Celulose** | 1 | 1 | Spinnova | Corporation | BRA |
| **Fidelity International** | 1 | 1 | Spiber | Venture Capital | GBR |
| **Fidelity Management & Research** | 1 | 1 | Bolt Threads | Private Equity Firm | USA |
| **Fifty Year** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **Fiona Sobek** | 1 | 1 | Bucha Bio | Individual/Angel | CHN |
| **Firstminute Capital** | 1 | 1 | VitroLabs | Micro VC | GBR |
| **Flight Ventures** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **For Good Ventures** | 1 | 1 | Natural Fiber Welding | Venture Capital | USA |
| **Future Shape** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **George Godula** | 1 | 1 | MycoWorks | Individual/Angel | CHN |
| **George Sobek** | 1 | 1 | Bucha Bio | Individual/Angel | CHN |
| **Goldwind** | 1 | 1 | Spiber | Corporation | CHN |
| **GrayArch Partner** | 1 | 1 | Newlight | Venture Capital | USA |
| **Greater London Investment Fund** | 1 | 1 | Ananas Anam (Piñatex) | Fund of Funds | GBR |
| **Gruss & Co** | 1 | 1 | MycoWorks | Investment Management Firm | USA |
| **H/L Ventures** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **Hemisphere Ventures** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **Humboldt Fund** | 1 | 1 | MycoWorks | Venture Capital | USA |
| **Indian Angel Network** | 1 | 1 | Kanpur Flowercycling Private Limited (Phool) | Angel Group | IND |
| **Innovate UK** | 1 | 1 | Ananas Anam (Piñatex) | Venture Capital | GBR |

| | | | | | |
|---|---|---|---|---|---|
| **Innovation Endeavors** | 1 | 1 | Bolt Threads | Venture Capital | USA |
| **InnovationRCA** | 1 | 1 | Ananas Anam (Piñatex) | Accelerator/Incubator | GBR |
| **Innovationsfonden** | 1 | 1 | Beyond Leather/LEAP | - | DNK |
| **Interplay Ventures** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **Intesa Sanpaolo** | 1 | 1 | Save The Duck | For Profit | ITA |
| **JAFCO Japan** | 1 | 1 | Spiber | Early Stage Venture | JPN |
| **John Legend** | 1 | 1 | MycoWorks | Individual/Angel | USA |
| **Kevin McIntosh** | 1 | 1 | VitroLabs | Individual/Angel | USA |
| **Key Partners Capital** | 1 | 1 | Modern Meadow | Investment Firm | DEU |
| **Khosia Ventures** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **Kima Ventures** | 1 | 1 | VitroLabs | Micro VC | FRA |
| **Kirayaka Consulting & Partners** | 1 | 1 | Spiber | Consulting Firm | JPN |
| **KISKO** | 1 | 1 | Spiber | Corporation | JPN |
| **Kyle Vogt** | 1 | 1 | VitroLabs | Individual/Angel | USA |
| **LeFrak** | 1 | 1 | Bolt Threads | Private Company | USA |
| **Lenzing** | 1 | 1 | Spinnova | Corporation | AUT |
| **Lifely** | 1 | 1 | Bucha Bio | For Profit | ITA |
| **Markku Kaloniemi** | 1 | 1 | Spinnova | Individual/Angel | FIN |
| **Matthew Demeter** | 1 | 1 | VitroLabs | Individual/Angel | USA |
| **Metropolis Ventures** | 1 | 1 | ettitude | Venture Capital | USA |
| **MicroVentures** | 1 | 1 | Bucha Bio | For Profit | USA |
| **Mission BioCapital company** | 1 | 1 | Bolt Threads | Venture Capital | USA |
| **Mitsubishi HC Capital** | 1 | 1 | Spiber | Investment Firm | JPN |
| **Nan Fung** | 1 | 1 | Bolt Threads | Private Equity firm | CHN |
| **Natalie Portman** | 1 | 1 | MycoWorks | Individual/Angel | USA |
| **Network Society Ventures** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **New Climate Ventures** | 1 | 1 | Bucha Bio | Venture Capital | USA |
| **Nicholas Valeriano** | 1 | 1 | Bucha Bio | Individual/Angel | USA |
| **Nicolas Douay** | 1 | 1 | Faircraft | Individual/Angel | FRA |
| **Peter Kellner** | 1 | 1 | Modern Meadow | Individual/Angel | USA |
| **Prairie Crest Capital** | 1 | 1 | Natural Fiber Welding | Venture Capital | USA |
| **Proud.Ventures** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **QKZ Design** | 1 | 1 | Bucha Bio | Investment Firm | USA |
| **Ralph Lauren Corporation** | 1 | 1 | Natural Fiber Welding | Corporation | USA |
| **Red Swan Ventures** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **Rensselaer Polytechnic Institute** | 1 | 1 | Ecovative | Accelerator/Incubator | USA |
| **Ron Li** | 1 | 1 | VitroLabs | Individual/Angel | CHN |
| **Sake Bosch** | 1 | 1 | Faircraft | Individual/Angel | NLD |
| **Satake Chemical Machinery** | 1 | 1 | Spiber | For Profit | JPN |
| **Seedcamp** | 1 | 1 | VitroLabs | Venture Capital | GBR |
| **Senator Investment Group** | 1 | 1 | Ecovative | Hedge Fund | USA |
| **Serious Change** | 1 | 1 | Spiber | - | GBR |
| **Shinsei Bank** | 1 | 1 | Spiber | Investment Bank | JPN |
| **Siam Capital** | 1 | 1 | Ecovative | Venture Capital | USA |
| **Silicon Valley Bank** | 1 | 1 | Bolt Threads | Investment Bank | USA |
| **Singularity University Ventures** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **Smith Family Circle** | 1 | 1 | Modern Meadow | Investment Firm | USA |
| **Spark Ventures** | 1 | 1 | Ananas Anam (Piñatex) | Venture Capital | GBR |
| **Starlight Ventures** | 1 | 1 | Modern Meadow | Venture Capital | USA |
| **Startup 100** | 1 | 1 | Spinnova | Accelerator/Incubator | USA |
| **Steen Ulf Jensen** | 1 | 1 | Beyond Leather | Individual/Angel | DNK |
| **Stefano Bernardi** | 1 | 1 | VitroLabs | Individual/Angel | USA |
| **Stray Dog Capital** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **Susa Ventures** | 1 | 1 | MycoWorks | Micro VC, Venture Capital | USA |
| **TA Ventures** | 1 | 1 | ettitude | Venture Capital | DEU |
| **The Carlyle Group (CG)** | 1 | 1 | Spiber | Private Equity Firm | USA |
| **The Draper Richards Kaplan Foundation** | 1 | 1 | Kanpur Flowercycling Private Limited (Phool) | Micro VC, Venture Capital | USA |
| **The Venture Collective** | 1 | 1 | VitroLabs | Venture Capital | USA |

| | | | | | |
|---|---|---|---|---|---|
| **Third Seven Capital** | 1 | 1 | Newlight | Investment Bank | USA |
| **Timo Soininen** | 1 | 1 | Spinnova | Individual/Angel | CHE |
| **Tokyo Century** | 1 | 1 | Spiber | Investment Firm | JPN |
| **Toyoshima** | 1 | 1 | Spiber | Investment Firm | JPN |
| **Toyota Boshoku America** | 1 | 1 | Spiber | Corporation | USA |
| **Trousdale Ventures** | 1 | 1 | Ecovative | Venture Capital | USA |
| **Tsuruoka Shinkin Bank** | 1 | 1 | Spiber | Investment Firm | JPN |
| **Ulu Ventures** | 1 | 1 | Modern Meadow | Micro VC, Venture Capital | USA |
| **Vaekstfonden** | 1 | 1 | Beyond Leather | Venture Capital | DNK |
| **Valedor Partners** | 1 | 1 | Newlight | Private Equity Firm | USA |
| **Valor Equity Partners** | 1 | 1 | MycoWorks | Private Equity Firm, Venture Capital | USA |
| **VegInvest** | 1 | 1 | VitroLabs | Venture Capital | USA |
| **VentureWell** | 1 | 1 | Ecovative | Venture Capital | USA |
| **VF Ventures** | 1 | 1 | Beyond Leather | Investment Firm | DNK |
| **Viking Global Investors** | 1 | 1 | Ecovative | Private Equity Firm | USA |
| **Vishal Harpalani** | 1 | 1 | VitroLabs | Individual/Angel | USA |
| **Vision Ventures** | 1 | 1 | Modern Meadow | Individual/Angel | SAU |
| **VTT Ventures** | 1 | 1 | Spinnova | Venture Capital | FIN |
| **WTT Investment** | 1 | 1 | MycoWorks | Venture Capital | TWN |
| **Y Combinator** | 1 | 1 | VitroLabs | Accelerator | USA |
| **Yrjö Neuvo** | 1 | 1 | Spinnova | Individual/Angel | FIN |

*Source: MII analysis on investment activities in companies included in MII's company database, based on data from primary research and secondary research (on databases including but not limited to CrunchBase, PitchBook, and SPEEDA Edge).*

Have we missed anything? Are you an investor interested in the next-gen material industry? Please contact us via this form.

# Capital

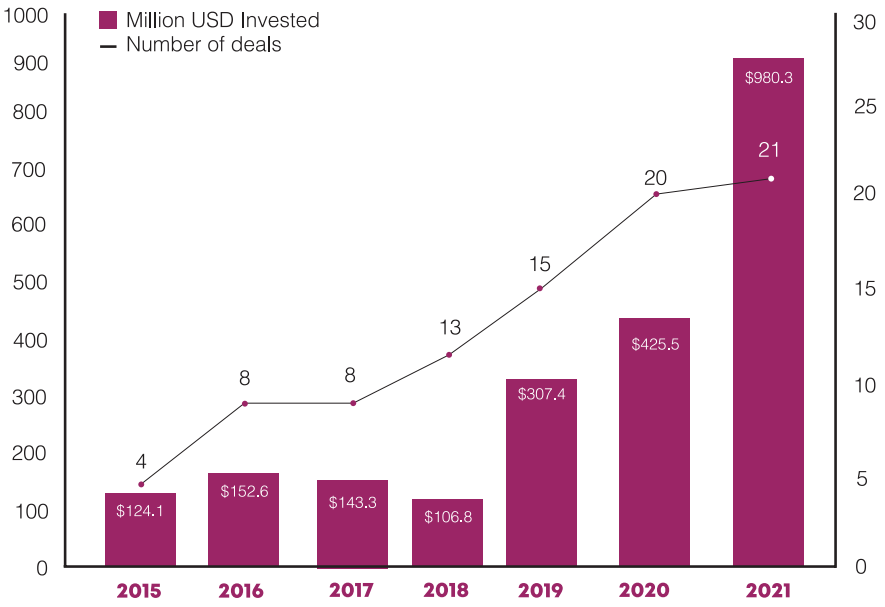
Investment in next-gen material innovation reached new heights in 2021.

**The investment amount in the year of 2021 more than doubled that from in 2020.** Moreover, dollars invested in 2021 alone was nearly the same as the previous 4 years combined, even amid the Covid-19 pandemic.

The number of deals has not drastically increased from 2020 to 2021 but dollars invested has more than doubled, demonstrating bigger deal sizes are to be expected as companies mature, show proof of concept, and scale.

*Please note that the figures published in this report may differ from prior figures published by MII as we continually improve our dataset.*

**Table 4.2**
**Annual investment in next-gen material companies (2015-2021)**




*Source: MII analysis on investment activities in companies included in MII's company database, based on data from primary research and secondary research (on databases including but not limited to CrunchBase, PitchBook, and SPEEDA Edge).*

WEREWOOL

# Companies

The following are the 10 top-funded next-gen material companies listed in table 3.1, according to publicly disclosed data.

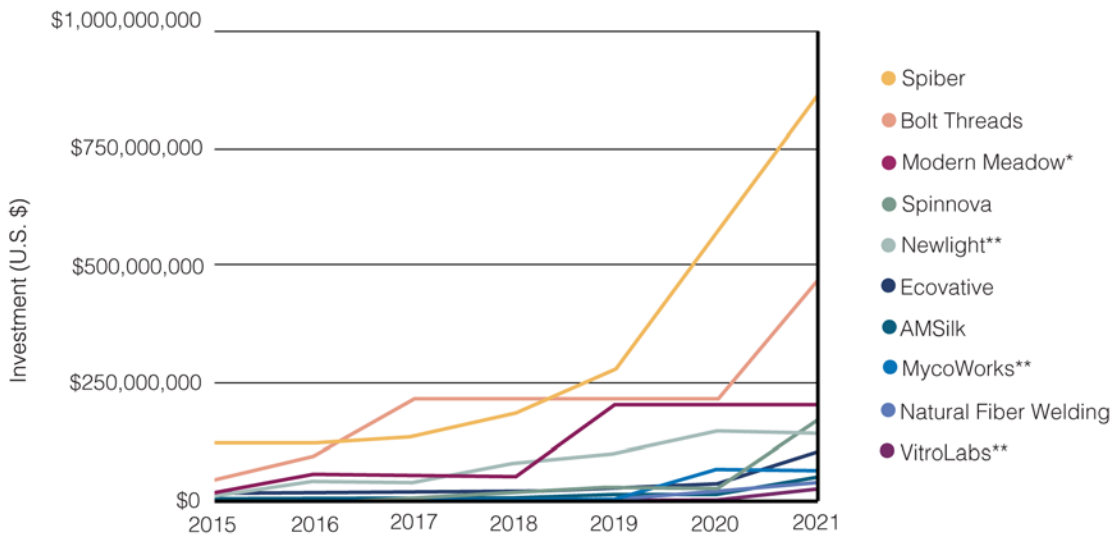
**Table 4.3**
**Top 10 most funded next-gen material companies** (in descending order by total amount raised)

| Company | Brief Company Description | Largest round (USD) / date | Total amount raised (USD) / Latest Round |
|---|---|---|---|
| **Spiber** | Produces spider silk proteins via precision fermentation to create next-gen silk. Collaboration with the designer Yuima Nakazato. | 217.5M / Dec 2020 | 863.6M / Private Equity |
| **Bolt Threads** | Grows mycelium to produce next-gen leather and uses precision fermentation to produce spider silk proteins for next-gen silk. Collaboration with Adidas, Kering, Lululemon, Stella McCartney. | 253.0M / Sep 2021 | 471.1M / Series E |
| **Modern Meadow*** | Develops a technology application platform, including a protein and bio-polymer blend that is applicable to next-gen leather. | 151.7M / Apr 2021 | 335.3M / Series C |
| **Spinnova** | Uses FSC-certified wood and waste streams to produce next-gen wool. Collaboration with Marimekko, H&M, Bergans of Norway, Bestseller (Fashion FWD). | 139.1M / Jun 2021 | 168.0M / Public Company |
| **Newlight**** | Uses natural ocean microorganisms to make PHB from greenhouse gasses to produce next-gen leather. Collaboration with Nike. | 45.1M / Sep 2020 | 145.6M / Series F |
| **Ecovative** | Grows mycelium on agricultural waste to produce next-gen leather. | 60.0M / Mar 2021 | 97.4M / Series D |
| **AMSilk**** | Makes spider silk proteins via precision fermentation to produce next-gen silk. Collaboration with Adidas, Airbus. | 34.9M / May 2021 | 76.7M / Series C |
| **MycoWorks**** | Grows mycelium to produce next-gen leather. Collaboration with Hermès. | 45.0M / Oct 2020 | 66.8M / Series B |
| **Natural Fiber Welding** | Produces plant-based, plastic-free material with customizability that can look and feel like leather, or carbon fiber. Collaboration with Allbirds, Ralph Lauren, Richemont, Melina Bucher, and others. | 15.0M / Jul 2021 | 43.4M / Venture Round |
| **VitroLabs**** | Uses stem-cell technology and tissue engineering to cultivate real skins to produce next-gen leather/exotic skins. | 21.7M / Sep 2021 | 24.8M / Series A |

**Modern Meadow has formed a new joint venture BioFabbrica LLC with Limonta, an Italian textile and materials supplier, to focus on development of next-gen leather.*
***Company with one or more rounds of undisclosed amount. Undisclosed amounts are not reflected in the total amount raised in this table.*

*Source: MII analysis on investment activities in companies included in MII's company database, based on data from primary research and secondary research (on databases including but not limited to CrunchBase, PitchBook, and SPEEDA Edge).*

**Figure 4.4**
**Funding history of top 10 funded next-gen material companies**




**Modern Meadow has formed a new joint venture BioFabbrica LLC with Limonta, an Italian textile and materials supplier, to focus on development of next-gen leather.*
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*Source: MII analysis on investment activities in companies included in MII's company database, based on data from primary research and secondary research (on databases including but not limited to CrunchBase, PitchBook, and SPEEDA Edge).*

# Case Study

BUCHA BIO

As illustrated above, the more familiar names in the space have all raised quite a few rounds of funding, and one has already gone public. If you are interested in investing, what does an early stage, pre-seed next-gen material startup look like?

Zimri T. Hinshaw founded Bucha Bio in 2019 and raised an oversubscribed $550K seed round in 2021 to scale up the production of Shorai™, a next-gen material alternative to leather.

**Tech:**
Bucha Bio makes novel biomaterials by combining fermented bacterial nanocellulose with plant-based biopolymers and additives. Bacterial nanocellulose is a natural polymer created by strains like *Gluconacetobacter xylinus*, one of the strains found in Kombucha tea. The NYC-founded now Houston-based startup blends the material created by this process with natural fibers. This in turn produces, in the company's own words,"high-performance textiles and composites" that can be alternatives to animal and petrochemical-based materials like leather, vinyl, latex, and epoxy.

**Positioning:**
The business model is for the company to remain as the creator of the formulation, outsourcing production, and working with customers to produce materials onsite. Bucha Bio is positioning itself as a biotech company, as opposed to a manufacturer. The strategy is to hand production over to other, bigger companies to achieve a significantly larger reach, quicker. And ultimately, creating a much greater environmental impact in a shorter time.

**Use Cases:**
Shorai™ has a number of use cases that vary depending on how thick the material is cast or extruded and the ratio of bacterial nanocellulose to other ingredients. For example, a piece 1 millimeter thick makes a suitable material for a jacket. Thicker sheets could be used to replace the vinyl on a car dashboard or even make hard composites like those found in construction. Extremely thin pieces could be used in packaging. Which means Bucha Bio is looking at not only the fashion industry, but also home goods and automobiles, or even packaging and construction materials.

***"The market and brands' attitude towards next-gen materials have drastically changed. In our first two years in business, we made hundreds of cold calls to brands. In the past year, all calls have been inbound."***

***Zimri T. Hinshaw***
***Founder and CEO, Bucha Bio***

BUCHA BIO


## IN

**"I had the pleasure of meeting with Zimri and examining Bucha Bio's material at its early development stage. Over six months I looked at more than 10 iterations from Zimri and his team. The very first batch of swatches I tested were quite rustic and unlike materials you see in traditional fashion. The material was coarse and did not share the usual characteristics of leather. It also had a slightly unpleasant scent.**

**However, subsequent material iterations were astonishing. With every meeting, they showed me swatches that were vastly improved from the previous. They were listening to the feedback. Surfaces and aesthetics were improving each time; and they introduced a new non-toxic color. Performance is probably the biggest hurdle for most next-gen material makers. Tensile strength, water resistance and color fastness are high bars to clear. Within a six month period, I witnessed improved malleability/drape, surface appeal and hand feel. They also improved their material's performance – they now had a material that was abrasion-proof and had tensile strength.**

**Interestingly, while developing material swatches to replace leather, they were also seeing white space opportunities that they hadn't originally planned for. I love that they always keep their eyes and minds open to creating sustainable inputs and materials with a variety of end-uses. They have the right attitude for success."**

**Thomasine Dolan**
**Fashion Design Specialist**
**Material Innovation Initiative**

# 5. INDUSTRY BRANDS

## Overview

Industry brands are established companies in fashion, automotive, and home goods that are the biggest buyers and users of materials. Although consumer preference has driven brands in these industries to move towards more sustainable practices, material innovators seldom have a direct relationship with consumers. The success of transitioning from animal-based materials to next-gen materials largely depends on innovators' ability to work with industry brands.

Industry Brands can play multiple important roles in the ecosystem, including funding both internal and external innovation initiatives, switching to next-gen materials as their raw materials, and collaborating with next-gen material startups to create new products. All this leads to acceleration of commercialisation and scale-up production of next-gen materials to replace their conventional counterparts.

In February 2022, the Material Innovation Initiative (MII) published a first-of-its-kind report: Brand Engagement with Next-gen Materials: 2022 Landscape. The report details how fashion, automotive, and home goods brands are using next-gen materials in their product lines in order to match shifting consumer demand, increase environmental sustainability, and address growing animal welfare concerns.

**IN**

**"MII has met with 40 leading fashion brands, and all but two are actively searching for next-gen materials to integrate into their supply chains.**

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

**Nicole Rawling**
**Chief Executive Officer**
**Material Innovation Initiative**

Brands in fashion, automotive, and home goods are integrating next-gen materials into their products through: **partnerships, in-house innovation, investment, and advisory services**. The Brand Engagement with Next-Gen Materials: 2022 Landscape report explains each of these strategies with over 150 examples involving these first mover brands:

**Figure 5.1**
**List of first mover brands.**

## 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
Norrona

**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
Serapian
Skagen
Stella McCartney
Stüssy
Sylven 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

Source: Brand Engagement with Next-gen Materials: 2022 Landscape by MII.
*This list contains brands mentioned in the source report. It is not an exhaustive list of brands using next-gen materials.

Why are these top brands in fashion, automotive, and home goods using next-gen materials? Quite simply, these brands expect to increase revenue by exemplifying their positive effect on the environment and animals. The majority of industry brands' environmental impact comes from their raw materials: most brands estimate between 60-80 percent of a product's environmental footprint is from the raw material alone. Animal-based materials have some of the most significant negative environmental impacts, whereas next-gen materials are poised to have lower environmental impacts than both animal-derived materials and current-gen synthetics.

Industry brands have set targets to lower their environmental footprint and these targets create concrete and predictable opportunities for material innovators. For example, H&M has pledged to use 100% sustainable or recycled material to manufacture products by 2030; Nike will increase the use of low-carbon materials to 50% of all "key materials" (defined as polyester, cotton, leather, and rubber) by 2025.[14]

**IN**

**"Many industry brands have specific, publicly disclosed targets and pledges to attain measurable improvements in sustainability. Given the significant impact raw materials have on a brand's environmental footprint, it is expected that these targets will be largely achieved through a transition from incumbent (and current-gen) materials to next-gen alternatives. These sustainability pledges, both in terms of volume and timeline, are therefore a good reference for material innovators and investors to gauge the potential market size and growth rate of the next-gen materials industry."**

**Elaine Siu**
**Chief Innovation Officer**
**Material Innovation Initiative**



PANGAIA

IN

**"The current materials industry does not yet produce sustainable options at scale that meet brands' performance, aesthetics, and price requirements. When we help brands source these next-gen materials, we encounter very few existing options that meet a brand's specifications and hit their sustainability goals. We continue to reiterate that perfection cannot be the enemy of good. In other words, although we are not quite there on 100 percent cradle-to-cradle sustainability, moving to next-gen raw materials will have significant positive environmental impacts.**

**Jacqueline Kravette**
**Board Member**
**Material Innovation Initiative**

What are the bottlenecks in transitioning to next-gen materials? In our first State of the Industry Report: Next-Gen Materials published in June 2021, MII reported that brands are excited to be pioneers and leaders in utilizing these materials, but they are also learning that it requires time, effort, and collaboration with innovators to form a true partnership. (See State of the Industry Report: Next-Gen Materials 2020 for more insights from designers' and manufacturers' perspectives.)

Another option for industry brands that want to integrate next-gen materials into their product lines is to conduct research and development in-house. In 2021, several major industry brands announced in-house developed next-gen materials, including Gucci's next-gen leather Demetra and Volvo's Nordico.

Industry brands like PANGAIA and Save The Duck are retail brands as well as material innovators with a business-to-business line that sells their proprietary materials to other brands. PANGAIA, for example, has over 200 fabrics and innovative materials in its portfolio including the next-gen down material FLWRDWN™ that it uses to produce Pangaia-branded products and supplies to other brands including H&M. Save The Duck uses its Plumtech® next-gen down filling material in its own product line and supplies to other brands including Disney.

PLUMTECH® BY SAVE THE DUCK x SATOSHI YAMANE

# Case Study

## Volkswagen

Volkswagen is aiming to reduce group-wide greenhouse gas emissions in the production and use of its cars by 30 percent compared with 2018 by 2030. The manufacturer has set itself the goal of being net climate-neutral by 2050. To achieve this target, Volkswagen is phasing out incumbent materials and integrating next-gen materials.

The first phase "sustainability 1.0" involves improvements to processes, but not changing the type of raw material used.

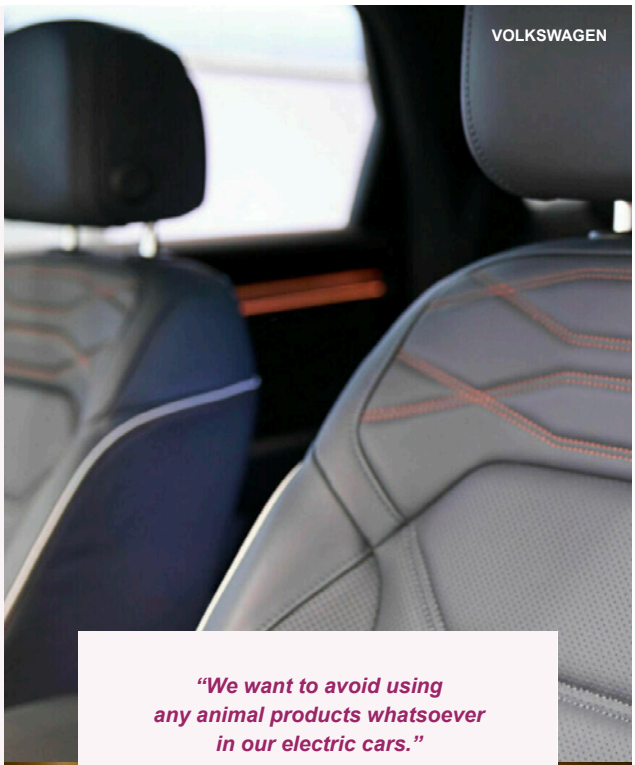
Volkswagen has used chrome-free leather for its vehicle interiors for the past 25 years.

The leather seats in the Touareg R plug-in hybrid are made from Puglia leather tanned using extracts from olive leaves.

To progress to sustainability 2.0, Volkswagen wants to move away from animal-based raw materials completely.

Although the company already uses non-animal leather alternatives, the in-house innovation team aims to increase the percentage of bio-based components. Currently working on coffee leather, Volkswagen is testing to further increase the percentage of organic material by replacing fillers with coffee silverskin, a by-product of coffee roasting. The company has already attained an impressive percentage of organic materials of more than 50 percent, and improved the ecological footprint of non-animal leather alternatives in the process.

As a global volume manufacturer, Volkswagen needs industrial-scale capability which they are currently getting from their coffee roasting house supplier producing on an industrial scale.




*"We want to avoid using any animal products whatsoever in our electric cars."*

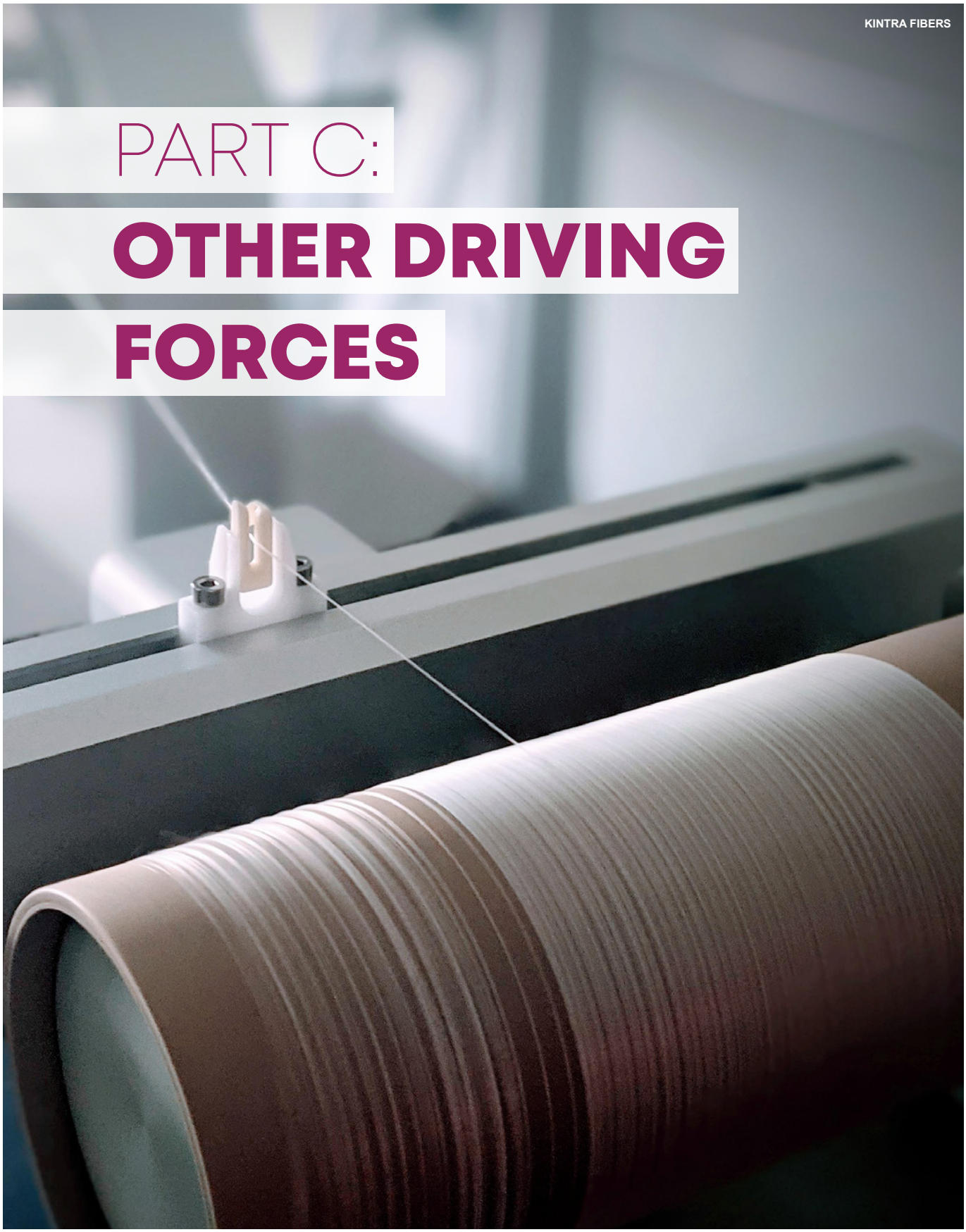
***Heike Hustedt***
*Color & Trim designer, Volkswagen*[15]

For sustainability 3.0, Volkswagen's vision is to create in a way that enables recycling. An important step on the journey is reducing the number of components, the number of elements of components, and the number of material layers in the component. The company is concurrently developing single-origin synthetics and has high hopes for PET and polypropylene that can be easily recycled. The ID.4 model seats are made from recycled plastic bottles.

***"It is not enough for a material to pass the right tests in the lab. It is just as important for our suppliers to be able to produce on a large scale, or to be ready to develop in this direction in collaboration with Volkswagen – and to expand themselves or change their offering in the process."***[16]

***Heike Hustedt***
***Color & Trim designer, Volkswagen***

VOLKSWAGEN


KINTRA FIBERS

# PART C: OTHER DRIVING FORCES

# 6. WHITE SPACES

In MII's report White Space Analysis 2021: The Next-Gen Materials Industry, we identified seven white spaces opportunities up and down the value chain of the materials industry. How fast the next-gen materials industry grows will largely depend on how attention and resources are directed to fill these gaps in existing markets

## 1. SUBCATEGORIES WITH LIMITED INNOVATION

**Sub-heading: silk, down, fur, wool, and exotic skins**

Approximately 70% of current players in the next-gen materials industry target next-gen leather, leaving silk, wool, down, fur, and exotic skins with limited innovation efforts. Silk, fur, and exotic skins in particular, are attractive for early stage innovators. High value product targets could enable a faster path to price parity than commodity markets. For example, polyester yarn hovers around $1/kg,[17] while raw silk averages around $55/kg.[18] These underserved product categories currently mean a lack of competition, which may be attractive to innovators and investors looking to enter the next-gen materials industry.

## 2. 100% "SUSTAINABLE"?

**Sub-heading: bio-based resins, coatings, binders, dyes, finishes**

Innovations in components of next-gen materials, including coatings and dyes, could lead to more holistically sustainable formulations. Innovation in sustainable alternatives to fossil fuel-derived polyurethane would make a big impact in the next-gen leather industry. PU is often the choice for binders or coatings because of its versatility and performance attributes. We need bio-based PU formulations reliant on green chemistry, or entirely new resins to lower environmental impact. Across all next-gen material categories, additives, dyes, and finishes should also be considered by material innovators and converters, as these inputs also play an important role in product sustainability.

## 3. BEYOND POLYESTER

**Sub-heading: 100% bio-based synthetic fibers**

Polyester is currently one of the most common and versatile formulation inputs for next-gen materials, finding use in nearly every product category. Innovation in sustainable synthetics is a target for the entire textile industry, but these efforts could apply to alternatives to animal-derived materials. Bio-based synthetic fibers can help reduce the reliance on petrochemical derivatives, and biodegradable fibers may enable alternative pathways at end-of-life.

IN

***"Sustainability is always a series of compromises based on priorities and we need a lot of people doing some things better, rather than a few people doing everything perfectly."***[19]

***Dr. Amanda Parkes***
***Pangaia's Chief Innovation Officer***

## 4. NEW BIOFEEDSTOCK

**Sub-heading: Biodiscovery and processing innovation for natural and cellulosic fibers and materials**

Natural and cellulosic fibers and materials are another versatile input for next-gen formulations. Novel biofeedstock, derived from agricultural waste or low impact natural resources are currently attractive opportunities for next-gen innovators. Billions of tonnes of unused agricultural waste products around the globe have potential for use in cellulosic or natural fibers. There is also a wealth of opportunity in process solutions to transform nature-based derivatives into scalable, high performance next-gen products.

## 5. LET'S GET VERSATILE

**Sub-heading: Multiple pathways at end-of-life**

Impending regulations and cost incentives will continue to push end-of-life waste strategies to the forefront. New textile materials entering the market are under pressure to fit into a closed-loop supply chain. While many of the circular end-of-life options show promise, they are also plagued with bottlenecks to implementation. We currently landfill or incinerate nearly 75% of our textiles.[20] Next-gen material innovators have an opportunity to design-in versatile end-of-life strategies into their products to meet these needs and reduce consumer burden.

## 6. MATERIALS SCIENCE DONE RIGHT

**Sub-heading: Bottom-up material design**

The incumbent animal-derived materials rely on intricate interplay between composition, structure, and properties to achieve their performance. Innovators looking to replace these incumbents in the form of next-gen materials should start from the bottom-up: designing materials that closely mimic the hierarchical structure and composition of leather, silk, wool, down, fur, and exotic skins. Using iterative materials science principles and biomimicry, next-gen materials can more closely resemble and perform like the incumbents.

## 7. BIOTECHNOLOGY SCALE-UP

**Sub-heading: Cellular agriculture at scale**

Next-gen innovators have begun to explore the opportunities of cellular agriculture to produce sustainable alternatives to animal-derived products. Using cultivated animal cells, mycelial growth, or building blocks derived from microbes, these approaches may transform materials manufacturing. However, these budding technologies rely on new-to-the-world science and underdeveloped manufacturing at-scale, with multiple pain points in need of resolution. Strain engineering, optimization of media/process conditions, and the conversion of raw outputs to finished products are each ripe for targeted innovation to mitigate risks during scale-up. Stakeholders in the next-gen industry should understand that biotech innovation requires investment and patience to be successful.

**IN**

**At the Material Innovation Initiative, we believe in making progress with the goal of perfection; perfection should not be the enemy of better. We trust that most innovators will rely on the best available options for sustainable formulation components, but completely phasing out less sustainable chemistries and additives is not always easy.**

**In order to come to grips with white space in the next-gen material industry, we need to understand the following:**

- **We should not expect next-gen innovators to single-handedly solve the vast challenges of disrupting the global textiles, chemicals, and additives markets.**
- **Performance and aesthetics are absolute requirements for next-gen products, and meeting them may require sacrifices in certain areas of sustainability at this time.**
- **The research, development, and scale-up associated with novel, sustainable material feedstocks and chemistries that can be adopted by next-gen innovators takes time and investment.**
- **There is no such thing as a "perfectly sustainable" material or product."**

**Dr. Sydney Gladman**
**Chief Science Officer**
**Material Innovation Initiative**

# 7. CONSUMER PREFERENCE

Although consumers appreciate the quality of animal-based materials, their impact on the environment and on animal welfare continue to give rise to demand for high quality alternatives that are in line with consumers' values. This expectation of values orientation in fashion choices is especially prominent among younger generations.[21]

Material Innovation Initiative undertook several studies to obtain preliminary data on consumer interest in and reasons for purchasing next-gen alternatives, as well as consumer perceptions of product attributes, openness to different production technologies, pricing, and preferences for message framing.[22] Currently, little data exists regarding consumer acceptance of any next-gen materials, much less data that facilitates basic comparison between two major geographic markets. These exploratory studies begin a research agenda to better understand consumer attitudes and behavior toward new materials that are high performance, more sustainable, and animal-free.

**IN**

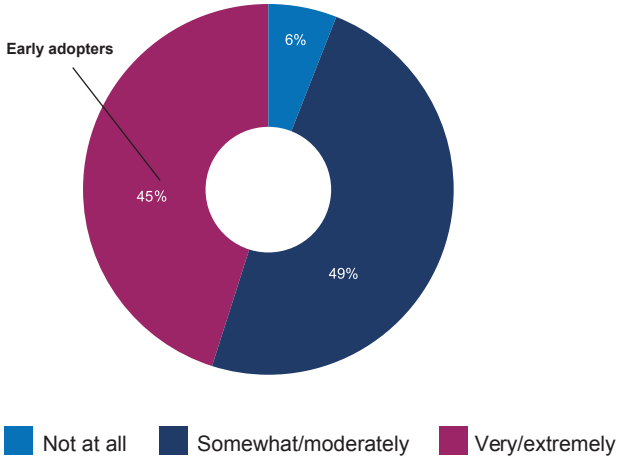
**"Our study showed that consumers who prefer animal-based leathers do so because animal leathers are seen as having higher quality and performance attributes. These consumers will be open to switching when next-gen leathers are at price, quality, and performance parity. Most consumers will even be willing to pay more for products made from next-gen materials that align with their values."[23]**

**Keri Szejda**
**North Mountain Consulting Group**

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

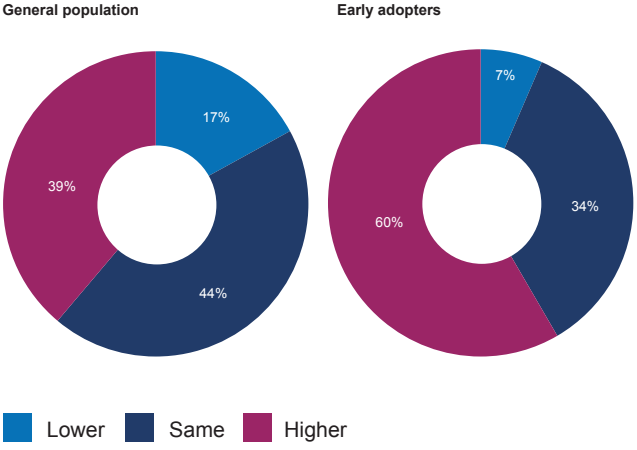
A study by MII and North Mountain Consulting Group released in September 2021 showed that in the United States, nearly all participants – 94% – stated they were at least somewhat likely to purchase next-gen materials, and nearly half – 45% – were highly likely to purchase.[24] The respondents who reported a high level of purchase interest (*very or extremely likely to purchase*) are classified as "early adopters."

### Likelihood of purchasing next-gen materials



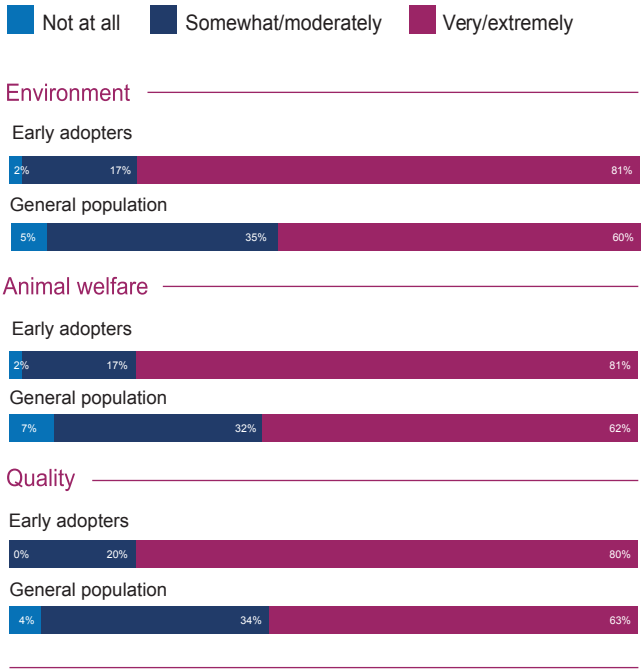

More than a third – 39% – of the general population said they would pay more next-gen materials and more than 60% of early adopters said they would pay more.[25]

### Degree of importance of reasons to purchase next-gen materials



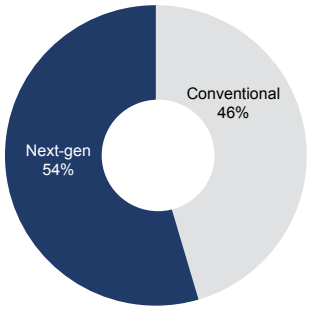

The main motivations for purchasing next-gen material was tied for early adopters with both animal-welfare and the environment tying at 81%. The general population is slightly more interested in next-gen materials for animal welfare reasons with animal welfare listed by 62% as the top motivator and the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

### Likelihood of purchasing next-gen materials

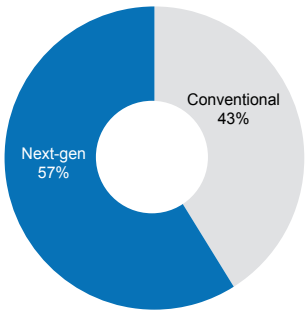



This analysis estimated that the market share for next-gen products would be over half of total purchases for each material subcategory: 54% of leather, 57% of wool, 60% of silk, 61% of down, 66% of fur, and 63% of exotic skins.[26]

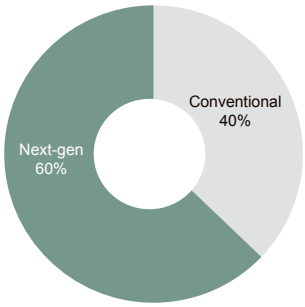
### Potential market share: Leather



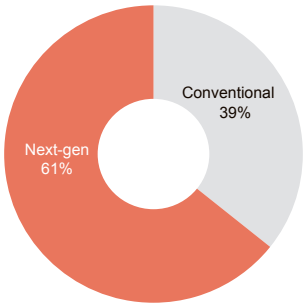

### Potential market share: Wool



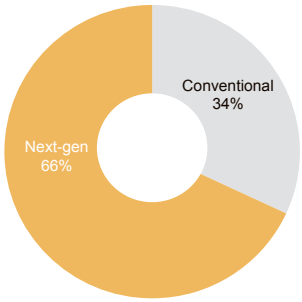

### Potential market share: Silk



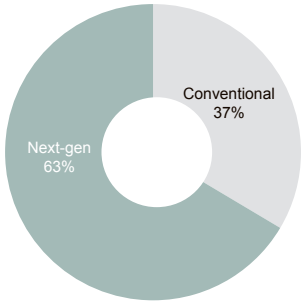

### Potential market share: Down




### Potential market share: Fur




### Potential market share: Exotic skins

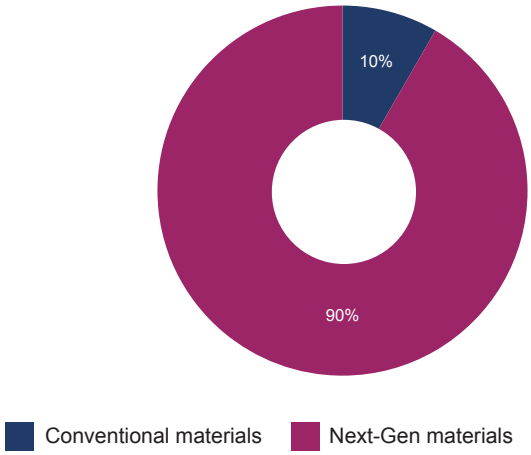



## Next-Gen Leather: Chinese Consumer Perceptions

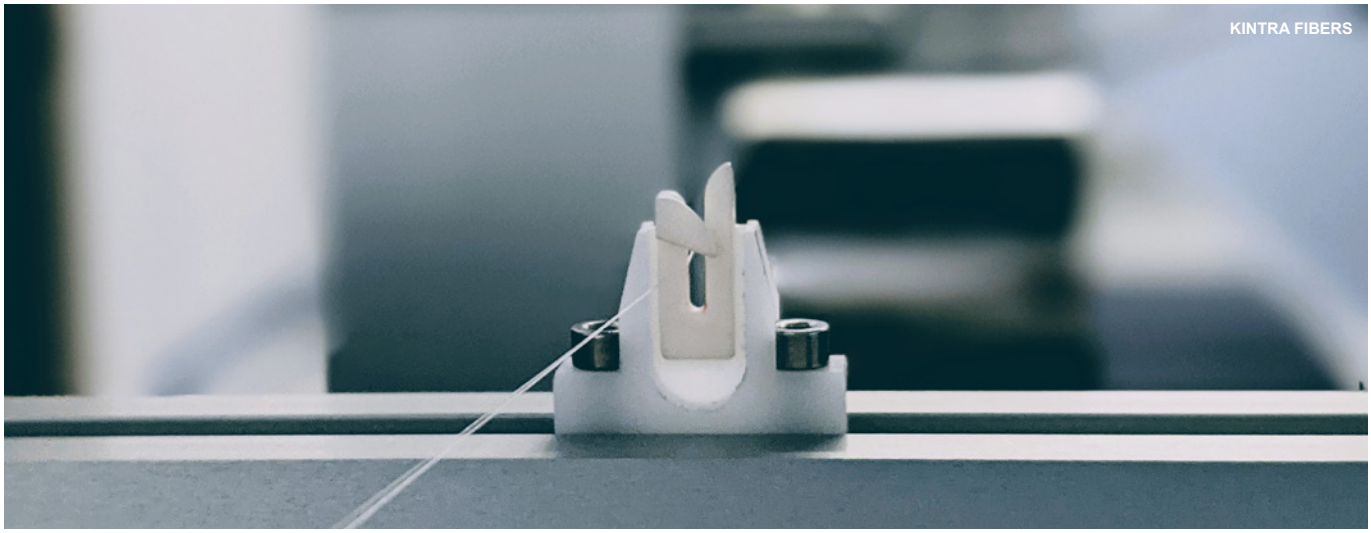
In a 2021 survey of consumers in China, where the vast majority of animal leather is produced, the results were astounding: "The study showed the highest rates of acceptance toward a new technology I have yet seen - 90% of the participants selected a next-gen product over conventional and 70% reported a high likelihood of purchasing," said Keri Szedja, Founder & Principal Research Scientist of NMCG.[27] 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.

### Material type preference by generation

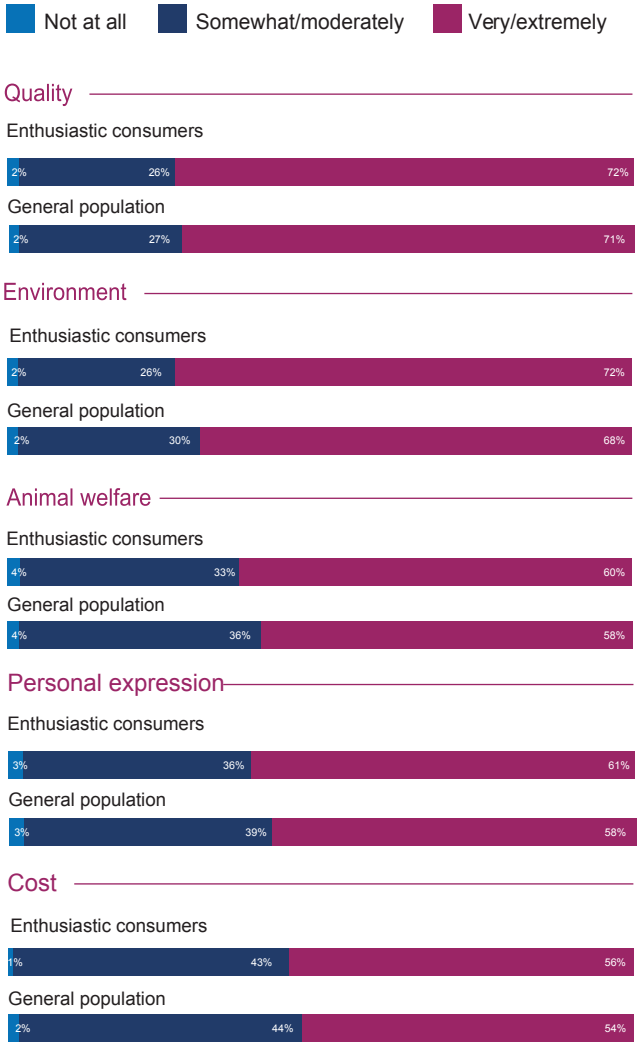
**General population**




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%).

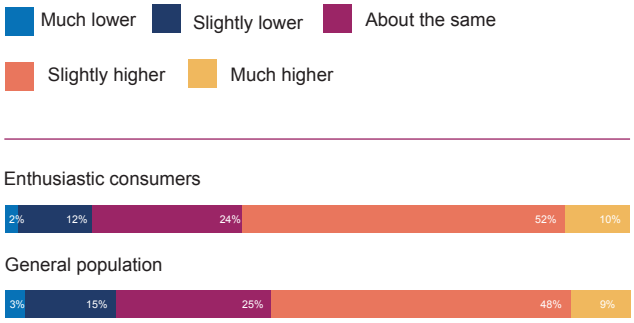

KINTRA FIBERS

## Motivations for purchasing next-gen leather




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




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.

# 8. REGULATORY OPPORTUNITIES

## A. NEED FOR SOLUTIONS TO THE SUSTAINABILITY CRISIS

Left unchecked, the fashion industry is projected to take up more than a quarter of the global carbon budget by 2050.[28] The total carbon emissions from textile production amounts to 1.2 billion tons annually, more than the emissions of all international flights and maritime shipping combined.[29] At the end of life, we currently landfill or incinerate nearly 75% of our textiles; fewer than 1% of clothes of all material mixes are recycled.[30, 31] Fast fashion's excess makes the seemingly virtuous clothing donation path less than optimal. Ghana's largest port is currently a stark example of the environmental and financial nightmare for overwhelmed secondhand clothing converters, with overpacked landfills leading to methane emissions and ocean-bound waste.[32]

World leaders and local governments alike must find solutions to this sustainability crisis quickly. Ideally, solutions would get to the root of the problem, make the biggest impact, and result in economic growth and creation of new, more future-proof jobs (see section C below).

The most impactful area to focus on may well be raw materials. Between 66 and 80% of a fashion brand's environmental footprint comes from its choice of raw materials.[33] Animal-derived materials require nearly 4 billion animals and over 1 trillion silkworms for use of their skin, fur, silk, or feathers each year.[34] Dependence on animals for raw materials extends to a dependence on massive amounts of water, land, and high carbon emissions to support the industry, exacerbating climate change. 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.[35, 36] 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."[37] 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,[38] which has 25 times the radiative force of an equal mass of carbon dioxide.[39] The impacts of animal-derived materials are impossible to ignore.

In the first generation of animal-free alternatives, petrochemical-derived polyvinyl chloride (PVC) or polyurethane (PU) "leather," nylon or polyester "silk." or acrylic "wool," offered affordable, high-performance replacements for incumbent materials but did not solve environmental impact issues. In fact, microplastics and microfiber pollution from synthetics have led to a new crisis, where these prevalent and persistent particles, found in our water, land, air, and even living organisms such as ourselves, act as sponges for hazardous chemicals. Other alternatives, such as classic forms of plant-derived rayon, offered affordable, high-performance replacements for silk but contributed to resource depletion (e.g. deforestation) and poorly managed effluents.

As a result, policymakers need to look beyond the current-gen replacements and into next-gen materials as a significant piece of the puzzle to solve the sustainability crisis.

## B. INCREASING RESTRICTIONS ON ANIMAL-BASED MATERIALS

In the past two decades, concern for animal welfare has brought about an increase in the number of animal welfare certifications, as well as bans on certain husbandry practices and on the production or use of certain animal-based materials. In recent years, increased awareness and concern about the adverse impact of animal agriculture on the environment has added momentum to the shift away from reliance on raising animals for human consumption, from what we eat to what we wear.

More stringent restrictions on the production of animal-based materials and outright regulatory bans of certain materials will continue, especially as the market offers consumers more choices that meet their aesthetic and performance needs and are cruelty-free and more sustainable. Examples of bans and restrictions include:

**Individual company level:**

- Fashion and luxury 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.[41]
- Dolce & Gabbana is ditching fur and angora[42] while Valentino has announced the plan to go fur-free.[43] Fashion luxury conglomerate (Kering) behind Gucci, Yves Saint

Laurent, Alexander McQueen and Balenciaga is banning the use of animal fur across all of its brands by fall 2022.

- Canadian outerwear brand Canada Goose announced they would be going fur-free[44] and Moncler said it will stop sourcing fur in 2022, with Autumn/Winter 2023 being the last collection to feature fur in its products including Moncler's signature puffer jackets.[45]
- Some luxury brands such as LVMH[46] and Hermès[47] have expressed their concern for animal welfare by building new production facilities and bringing the production of exotic skins under their control. Hermès is also betting on next-gen mycelium leather through a partnership with MycoWorks.[48]
- Major retailers such as Bloomingdale's, Macy's, Nordstrom, Neiman Marcus, Bergdorf Goodman, Saks Fifth Avenue, and H&M have taken fur off their racks.[49]
- Media empire ELLE banned fur from its pages across 45 editions and 46 websites in December 2021.[50] InStyle Magazine has banned exotic skins from its pages.[51]

### Industry level:

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;[52] Textile Exchange's Responsible Leather, Wool, Down, Mohair, and Alpaca Standards;[53] and Kering's Animal Welfare Standards.[54]

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.[55]

### Country level:

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.[56]

Although bans show a shift in consumer and brand preference and perception, suitable replacements must be available in the wake of these bans. The current-gen, traditional synthetics are not that solution: the market needs continued growth in low impact, high performance alternatives in the form of next-gen materials.


PIÑATEX x MĀRĪCĪ

# C. THE TARIFF DISPARITY

Currently, incumbent materials and next-gen materials are not operating on a level playing field. One factor contributing to the high cost of next-gen materials compared to their incumbent counterparts is the disparity in tariffs. One example is the tariff disparity between animal-based materials and sustainable materials enshrined in the U.S. Harmonized Tariff System (USHTS):

- In the case of footwear, the tariffs on the same type of footwear may be subject to different tariff rates depending on its material composition. For example, golf shoes that are primarily made of leather are subject to a tariff of 5 percent, but the same golf shoes made of rubber or plastic enter the United States at a 6 percent tariff.[57] The disparity is even larger for tennis shoes. Leather tennis shoes are subject to an 8.5 percent tariff, but plastic or rubber tennis shoes are subject to a 20 percent tariff.[58] This tariff disparity extends to shoe parts and penalizes sustainable shoe manufacturing in the United States. For example, formed uppers made of leather are subject to 8.5 to 10 percent tariffs, while formed uppers made of textile materials are subject to 10.5 to 26.2 percent tariffs upon entry.[59] The large difference in tariffs incentivizes shoe manufacturers to use leather parts over other textile materials.

- In the case of apparel, for example, men's overcoats that contain leather and animal fibers are subject to tariffs ranging from merely 0.9 percent for silk, to 5.6 percent for leather, to approximately 10 percent for wool.[60] The same men's overcoats made of cotton are subject to a significantly higher 15.9 percent tariff.[61] Furthermore, men's overcoats made of man-made fibers, such as sustainable, next-gen materials, are subject to a 28.2 percent tariff.[62]

- Women's suits made of synthetic fibers that contain more than 23 percent wool or fine animal hair by weight enter the United States tariff-free, while the same suits made of only synthetic fibers are subject to a 14.9 percent tariff.[63]

The examples above illustrate how tariff disparities encourage designers and the fashion industry as a whole to add animal materials to their products to avoid tariffs. The tariff disparities also encourage U.S. importers to import footwear and apparel that include animal products for further manufacturing or sale. Instead of incentivizing the use of more environmentally friendly products and materials, the U.S. government tariff policies incentivize the use of animal products and the resulting environmental harms.

To begin to solve the sustainability crisis, the U.S. government must reform its tariffs to encourage the use of next-gen materials. Other stakeholders have recognized this disparity, with Textile Exchange and notable brands placing a call for preferential tariffs for low impact textile materials at COP26.[64]

The global ethical fashion market size reached a value of nearly $6.35 billion in 2019, having increased at a compound annual growth rate (CAGR) of 8.7 percent since 2015.[65] The market is expected to grow to $8.25 billion in 2023, $9.81 billion in 2025, and $15.17 billion in 2030.[66]

The global ethical fashion market also represents opportunities for the creation of sustainable jobs. Championing the next-gen materials industry and encouraging consumers to move from animal-based to next-gen alternatives will support jobs in research and development and manufacturing and boost the local economy.

To strategically position themselves in this nascent next-gen materials industry, countries can use tax incentives and public funding to create competitive advantages in this relatively new global arena. Countries can reap the benefits of being first movers in an emerging industry by becoming an innovation hub that attracts talents and investments or a manufacturing center in the global supply chain, and/or by securing other major stakes in this inevitable shift to a more sustainable operation model.

# 9. CONCLUSION

The growth of the emerging next-gen materials industry is accelerating.

Conventional animal-derived materials such as leather, fur, silk, wool, down, and exotic skins, are widely used in the fashion, home goods, and automobile industries. Going forward, the greatest opportunities lie in developing technology and materials that inherently meet market demand for sustainability, style, and performance without the low margins, high variability, and myriad issues associated with using animals as inputs.

Of the 95 companies innovating in next-gen materials, sixty seven (67) work on biomimicry of animal leather, twelve (12) on biomimicry of silk, seven (7) on wool, six (7) on fur, six (6) on down, and one (1) on exotic skins.* Over half (55) of the 95 companies are relatively young, established after 2014.

**The investment amount in the year of 2021 more than doubled that from in 2020.** Moreover, dollars invested in 2021 alone is nearly the same as the previous 5 years combined, even amid the Covid-19 pandemic. The number of deals has not drastically increased from 2020 to 2021 but dollars invested has more than doubled, demonstrating bigger deal sizes are to be expected as companies mature, demonstrate proof of concept, and scale.

2021 saw the first exit in the nascent next-gen materials industry. Spinnova, Finnish technology company that uses FSC-certified wood and waste streams to produce next-gen wool, went public in June 2021. The company raised approximately USD135 million in the initial public offering of its shares on Nasdaq First North Growth Market Finland. Notably, adidas Ventures B.V. was one of the cornerstone investors in the IPO.

Industry brands have taken actions with respect to material innovation through partnerships, internal R&D, and investments (with over 150 examples featured in this report MII released in early 2022). Many brands also have sustainability commitments to completely switch to, or significantly increase the use of, more sustainable materials by a certain year. Such commitments present more opportunities for material innovators and suppliers.

Acceleration of the next-gen materials industry is fueled by advancements in science and technology, by consumer preferences, and by regulatory trends. Exciting white space opportunities are waiting to be exploited, those who are quick to adapt have the opportunity to reap massive financial benefits by staking their claim on the materials industry of the future.

Technologies and innovation have the potential to significantly transform the industry by creating materials that meet brands' and consumers' aesthetic, performance, and price needs and that are also more sustainable and animal-free. As we face potentially dire climate change, this is not the time to take it slow. We need significant investments, partnerships, and more material companies and scientists to disrupt the status quo.

Collaboration is the path forward. Now is the time to embrace sustainable innovation, both to create a liveable future on Earth and to create a prosperous future for the materials industry.

Let's make the sustainable option the default option.

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**Some companies work on more than one replacement of animal-based materials. 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 primary application in end products.*

# ABOUT MII

The Material Innovation Initiative is a nonprofit that accelerates the development of high-performance, animal-free, and more sustainable materials for the fashion, automotive, and home goods industries. We serve as a critical connector between key players along the path to market adoption of next-gen materials, partnering with scientists, startups, brands, and retailers to direct the industry toward areas of maximum impact.

We work for materials that can do more while requiring less of the planet, animals, and people involved at every stage. We imagine a circular future where the default choice for your sweater, sneaker, or seat is humane and sustainable; a future where animals are allowed to live free and thrive, where the planet is saved from pollution and degradation, and where workers are treated fairly and with respect.

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[57] Compare 6403.19.10 (Footwear with outer soles of rubber, plastics, leather or composition leather and uppers of leather; Sports footwear; Other; Golf Shoes) to 6402.19.05 (Other footwear with outer soles and uppers of rubber or plastics; Sports footwear; Other; Having uppers of which over 90 percent of the external surface area (including any accessories or reinforcements such as those mentioned in note 4(a) to this chapter) is rubber or plastics (except footwear having foxing or a foxing-like band applied or molded at the sole and overlapping the upper and except footwear designed to be worn over, or in lieu of, other footwear as a protection against water, oil, grease or chemicals or cold or inclement weather): Golf Shoes).

[58] Compare 6403.99.60 (Footwear with outer soles of rubber, plastics, leather or composition leather and uppers of leather; Other; Other; For men, youths and boys) with 6402.91.80, 6402.99.80, and 6402.99.90 (Other footwear with outer soles and uppers of rubber or plastics).

[59] Compare 6406.10.05 and 6406.10.10 with 6406.10.20, 6406.10.25, 6406.10.30, 6406.10.35, and 6406.10.40.

[60] See 6101.30 (Men's or boys' overcoats, carcoats, capes, cloaks, anoraks (including ski-jackets), windbreakers and similar articles, knitted or crocheted, other than those of heading 6103); 6101.30.10 (Of man-made fibers; Containing 25 percent or more by weight of leather); 6101.30.15 (Of man-made fibers; Other; Containing 23 percent or more by weight of wool or fine animal hair); and 6101.90.10 (Of other textile materials; Containing 70 percent or more by weight of silk or silk waste).

[61] See 6101.20.00 (Men's or boys' overcoats, carcoats, capes, cloaks, anoraks (including ski-jackets), windbreakers and similar articles, knitted or crocheted, other than those of heading 6103; Of cotton).

[62] See 6101.30.20 (Men's or boys' overcoats, carcoats, capes, cloaks, anoraks (including ski-jackets), windbreakers and similar articles, knitted or crocheted, other than those of heading 6103; Of Man-made fiber).

[63] Compare 6104.13.10 (Women's or girls' suits, ensembles, suit-type jackets, blazers, dresses, skirts, divided skirts, trousers, bib and brace overalls, breeches and shorts (other than swimwear), knitted or crocheted; Suits; of synthetic fibers; Containing 23 percent or more by weight of wool or fine animal hair) with 6104.13.20 (Women's or girls' suits, ensembles, suit-type jackets, blazers, dresses, skirts, divided skirts, trousers, bib and brace overalls, breeches and shorts (other than swimwear), knitted or crocheted; Suits; of synthetic fibers; other).

[64] Textile Exchange, "Fashion Industry Trade Policy Request: COP26, TextileExchange.org, Nov 8, 2021. https://textileexchange.org/trade-policy-request-cop26/

[65] The Business Research Company, "Sustainable Fashion Market Analysis Shows The Market Progress In Attempt To Decrease Pollution In The Global Ethical Fashion Market 2020," GlobeNewswire.com, Oct 28, 2020. globenewswire.com/news-release/2020/10/28/2116073/0/en/Sustainable-Fashion-Market-Analysis-Shows-The-Market-Progress-In-Attempt-To-Decrease-Pollution-In-The-Global-Ethicalfashion-Market-2020.html

[66] The Business Research Company, "Sustainable Fashion Market Analysis Shows The Market Progress In Attempt To Decrease Pollution In The Global Ethical Fashion Market 2020," GlobeNewswire.com, Oct 28, 2020. globenewswire.com/news-release/2020/10/28/2116073/0/en/Sustainable-Fashion-Market-Analysis-Shows-The-Market-Progress-In-Attempt-To-Decrease-Pollution-In-The-Global-Ethicalfashion-Market-2020.html

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