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A Report on Future Belongs to Biomaterials How Designers are Taking up the Challenge

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Abstract: *A biomaterial is a substance that has been engineered to interact with biological systems for a medical purpose, either a therapeutic (treat, augment, repair, or replace a tissue function of the body) or a diagnostic one. As a science, biomaterials is about fifty years old. The study of biomaterials is called biomaterials science or biomaterials engineering. It has experienced steady and strong growth over its history, with many companies investing large amounts of money into the development of new products. Biomaterials science encompasses elements of medicine, biology, chemistry, tissue engineering and materials science. Note that a biomaterial is different from a biological material, such as bone, that is produced by a biological system. Additionally, care should be exercised in defining a biomaterial as biocompatible, since it is application-specific. A biomaterial that is biocompatible or suitable for one application may not be biocompatible in another. Biomaterials can be derived either from nature or synthesized in the laboratory using a variety of chemical approaches utilizing metallic components, polymers, ceramics or composite materials. They are often used and/or adapted for a medical application, and thus comprise the whole or part of a living structure or biomedical device which performs, augments, or replaces a natural function. Such functions may be relatively passive, like being used for a heart valve, or maybe bioactive with a more interactive functionality such as hydroxy-apatite coated hip implants. Biomaterials are also used every day in dental applications, surgery, and drug delivery. For example, a construct with impregnated pharmaceutical products can be placed into the body, which permits the prolonged release of a drug over an extended period of time.*

Keywords: Biomaterial

I. Introduction

The use of biomaterials and their applications in a variety of fields, ranging from fashion to design to architecture and construction, is on the rise. And designers are responding to this revolution in different ways.

II. Design and Fashion

It is clear from recent proposals on the international stage that biobased materials inspired by design are the way of the future - at least in the near future. The abundance of experiences that design is sharing with scientists and researchers who are working on developing bio alternatives to synthetic products indicates a bright future for biomaterials. Is this just fruit of a temporary infatuation on the part of the design world or is it a harbinger of something more significant?

III. Biomanufacturing is the Future of Materials

One of the factors driving this trend is rapid progress in biomanufacturing. It is possible to manufacture biobased products using very specific raw materials, including cells, molecules, or extracellular matrices, some even derived from human skin. There is no limit to the production of natural materials that have been known for millennia, such as natural textiles, leather, wood and paper, which all come from animals and plants.

Biomaterial science and cellular biology have been working for a long time to create biomanufacturing technology that is widely available. The main field of interest is medicine, where the technology is crucial to studying and preventing rare diseases. In addition, these technologies provide an alternative to synthetic materials that will be used in the future by the biofuel industry to produce sustainable energy.

In addition, it's worth remembering that they're also useful in developing agricultural and food products that don't use animal parts or products, necessary given the expansion of veganism. Less in the spotlight is how biomanufactured technologies are being employed to create **biobased design materials** with applications in construction, architecture and industrial design.

IV. Biomaterials that have Emerged from the Design World

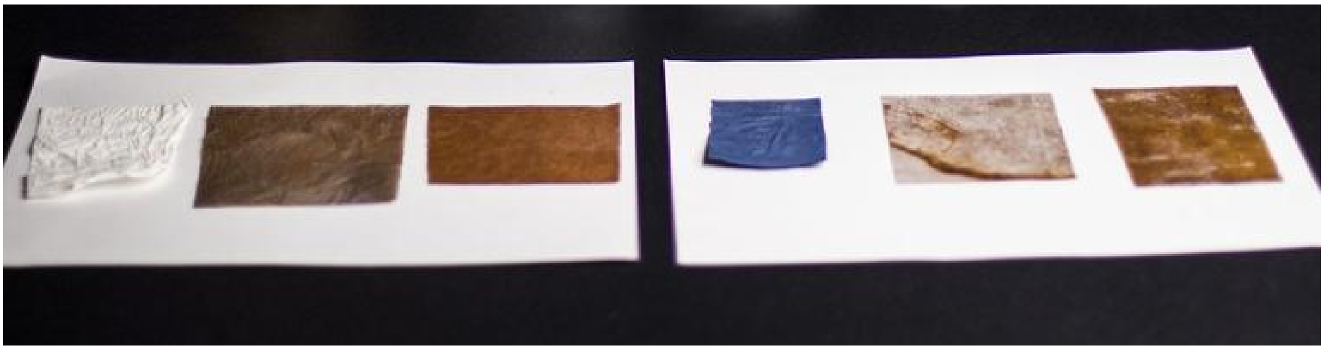
In some cases, the practice of design itself has led to experiments in which biologists, engineers and designers have created new, "design-driven" materials.

Mycoflex is a biomaterial made from 100 per cent pure mycelium. It's the main component of high-performance foams that have a wide range of applications, from sports shoes to light insulators for thermal gloves, and much more. Mycoflex is a vegan, non-toxic alternative to traditional synthetic foams and biodegrades naturally after use Ecovative

4.1 Modern Meadow

Modern Meadow is probably the most important example of this trend. The US design and research studio is a global pioneer in biomanufacturing advanced materials whose specific purpose is to offer new design possibilities. It was founded with the conviction that "multidisciplinary collaboration between design, biology and material science can lead to smarter ways to make evolved materials, inspired by nature and grown of life's essential elements: **cells, DNA and protein**".

This design and applied research studio based in Brooklyn, New York City has created the Zoa brand, a family of innovative materials based on a collagen protein tailor-made in the company's lab. Among other things, this protein has spawned a **new and completely biomanufactured material** inspired by animal skin, dubbed liquid leather because of its distinctive versatility.



Bacterial cellulose is a very versatile material and the BioFaber team, made up of designers, engineers, biotechnologists, plastic surgeons and researchers, has been able to create different processes with applications in sectors ranging from design to biomedics BioFaber

4.2 BioFaber

Italian startup BioFaber, based in the region of Puglia, was launched with the intent of creating new nano-structured biomaterials based on bacterial **cellulose**.

The bio-company led by designer is a perfect example of the circular economy in action: the production process is based on the symbiosis between **bacteria and fungi** already present in many food products.

BioFaber's hydrogel is transparent and elastic BioFaber

The transformation happens in an aqueous culture enriched with **sugars from food waste** such as molasses and olive residues, which are used by the microorganisms to synthesise the nanostructured cellulose. The latter self-assembles at room temperature and atmospheric pressure in a matter of weeks.

A **nano-structured, biocompatible polymer** emerges, one that can be customised to have particular traits. If necessary, it can be odourless, sterilised or hydrophobic.

From this technological starting point, the Brindisi-based company has created a sustainable material that in certain cases can replace use of animal skin and, in its **hydrogel** form, a series of materials aimed at the medical and biocosmetic sectors.

V. Biomaterials in the World of Fashion

It must be noted that the tendency to introduce bio-generated products isn't limited to design, and extends to the world of fashion. In certain ways, biomaterials have a **higher likelihood** of being applied in this field given that the required performance characteristics are technologically less complex.

5.1 Amsilk

Such is Adidas' case. It was one of the first companies to commit to this direction by introducing Biosteel fibres developed by German industrial supplier Amsilk into the manufacturing of its shoes. The **silk-like biopolymer** is obtained by decoding spider DNA then applied to a bacterium. Adidas has also produced a tennis outfit in biofabric, but it's still a prototype.

5.2 Spiber

Meanwhile, Japanese biotech startup Spiber has began selling the first sports garment in the world made entirely from **synthetic silk**: the Moon Parka, developed in collaboration with The North Face, was released on the market as a limited fifty-piece edition.

VI. Design Universities as Incubators for Biomaterials

In many European cities design schools offer Master's courses dedicated to the materials of the future and around the world, design universities are becoming **incubators for innovation** in this field. It's in this context that an increasing number of courses are being offered to young designers to work on the development of **low-impact materials** by collaborating with biologists, chemists and researchers.

An ever-growing number of design students choose to pursue Master's and PhDs in the development of new biobased materials. As has happened more frequently in recent years, the creation of startups and experimental labs within design schools is promoted via special contests and public grants. Most designers attending these innovation accelerators might seem like bricoleurs, amateurs in a new age, but it's likely that they're truly the **heroic vanguard** trying, on their own, to do what heavy industry has failed to do up to this point.

Plastic waste as a resource, how design can shape intelligent reuse.

Fiber shed is a sustainable and regenerative regional farming system that produces natural fibres used to create clothes © Paige Green

6.1 Green Lab

Green Lab, open to individual designers, organisations and companies, is one such places. Based in Bermondsey, in West London, it was created as an incubator for bio-circular economies, to develop and experiment in the ambit of unexplored aspects of the food chain, waste processing and the biosphere. In the past few years, it has benefited from contributions by many young designers with Master's degrees in the subject of Future Materials. As well being a hub to connect with key sustainability players in the UK, the lab also provides biodesigners with a **Grow Lab** where they can develop biomaterials, as well as "DIY" utensils and spaces in which to archive projects and experiments.

It isn't rare for profitable **startups** that give birth to new, alternative supplies for semi-manufactured and finished products to emerge in this context, although their reach tends to be mostly local.

Eggware: single-use biodegradable crockery made from eggshell waste Midushi Kochhar Startups experimenting with biomaterials

VII. Designers as Developers and Self-Producers

Young designers are the new alchemists. They define goals that set innovation challenges, create their own laboratories, work with chemists and researchers, and experiment to reach the results they've set themselves. In other words, they self-produce new materials, determining their structural and aesthetic characteristics. They decide what to create them from – nature or recycling – and how to transform them, cultivating alternative solutions to traditional materials that are environmentally weak or unable to adapt to new needs was still a design student when she developed the Immunotex project together with Margot Vaaderpass and Zaki Musa for the yearly Biodesign Challenge organised by London arts university Central Saint Martins. Immunotex is a travel clothing startup: it creates clothes and footwear designed to protect travellers from the growing threat of antibiotic-resistant bacteria. Its experiments have led to the Resistance Runner project, in which sports shoes are made from biobased fabrics that **use bacteriocins to protect wearers** from potential contamination.

The Resistance Runner is a bioengineered shoe that incorporates a cloned bacteriocin and micrococcus matrix in its manufacturing technology, which allows for the blocking and capturing of resistant bacteria. The matrix is based on a protective biofilm and needs to be recharged in a nutritional broth every seven days to remain activated and create an effective bacterial culture. The shoes, therefore, come with a ziplock bag that contains the "nutritional broth" and serves as a charging unit Resistance runner

It's a well-known fact that in recent years antibiotic-resistant bacteria have been emerging more prominently, posing a significant public health threat in the years to come. In this context, bacteriocins – substances produced by some bacteria that are able to combat the growth of phylogenetically similar bacteria – are being explored as alternatives to traditional antibiotics in factory farming and used in methods to contrast food contamination. platform to facilitate collaboration between startups, brands, sellers and research institutes.

7.1 Even Food Waste can become Biomaterials

Food processing waste also offers a wealth of possibilities that will fuel localised self-production in the future. The exploration of this frontier has already spawned new and unexpected materials. In the UK, Blast Studio Biological Laboratory of Architecture and Sensitive Technologies has developed a project in which the **pulp from recycled coffee cups** collected in London is reborn thanks to fungi's mycelium. Through this process waste is transformed into an organic material that can be used to make furniture and objects. To allow the pulp to be consumable by mycelium, Blast designs winged objects that can retain humidity, enabling the fungus to grow and generate the novel biomaterial.

A. Biomaterials from Coffee

Another designer, is behind that's Caffeine, a material made from **used coffee grounds** aggregated with organic binders, minerals and a plant-based resin. Its light, biodegradable, water-resistant as well as heatproof, and Durnel shapes it using traditional tools like buzz saws, or uses moulds to craft objects that he then sells online.

That's Caffeine, a material perfected by young designer, is made from recycled coffee grounds, biobinders, minerals and a plant-based resin that make it light, biodegradable and sustainable. Its water and heat resistant, which makes it suitable for use in kitchen and bathroom settings that's Caffeine .

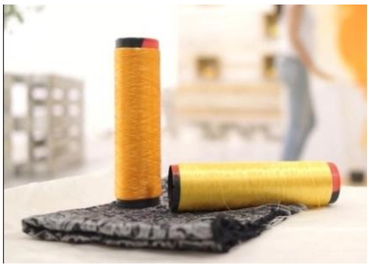
B. Biomaterials from Eggshells

Young designer Midushi Kochhar has experimented with the transformation of **eggshells** from the catering industry. With this chalky waste she creates **biodegradable, single-use crockery** as an alternative to plastic, which is often used to serve street food. With the right treatment this material might even have other applications, such as the creation of panelling for interiors, furniture and to be used in construction.

Eggware single-use tableware is biodegradable and locally produced: waste is transformed into something useful. The products are designed for eating on the go, suitable for serving street food as an alternative to non-biodegradable single-use plastic © Midushi Kochhar

C. Biomaterials from Oranges

A few years ago, Italian startup Orange Fiber patented and began producing a biomaterial made from processing the waste from Sicilian **citrus fruits**. It became **one of the first completely sustainable textile products** in the world: a gossamer fabric, soft and very similar to silk, perfect for low-impact fashion. In a field as collaborative and inclusive as that of new generation design, these "brand-materials" represent business models to be shared widely so that others can reproduce and develop them elsewhere.



Cellulose from citrus waste is made into a filament and subsequently an innovative fabric © Orange Fiber and then there's mycelium.

The regeneration of food processing waste isn't only a resource; it represents something much larger. Scaling up from the local to the global could occur quickly as the raw materials needed for **mass production of biomaterials** from this kind of waste are available in abundance. A new protagonist in the future of biobased materials is already emerging: **mycelium**.

Biologically speaking, it's the vegetative part of **fungi**. It's made up of a dense tangle of filaments that are conduits for protoplasm, which is made up of amino acids, proteins, lipids and polysaccharides. The material that originates from it can be considered a full-fledged polymer. The advantage of mycelium is that it performs the irreplaceable role of being a **natural aggregator**, which explains researchers' and designers' interest towards it as this functions allows for the creation of new materials from organic waste. In fact, fungi tend to grow on any organic matter that contains cellulose, a natural sugar-based polysaccharide which they consume.

The material obtained from fungi's mycelium grown in a mould – whose growth is interrupted through heating and dehydration at the end of the biochemical transformation – is inert and free of spores Ecovative .

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