# **BIOTECHNOLOGY, BIO-FABRICATION, BIO FASHION:** from living organisms to garments

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#### Abstract

From the outside, the fashion world promises bright lights, glamorous clothing, and accessories, but the side of the coin we don't see is pretty dark. When we evaluate the fashion industry in terms of both environmental pollution and the working conditions of the workers in the supply chain, unfortunately, a dark picture emerges. We started to realize, albeit late, how expensive the products that we produced cheaply actually cost us and our world, and then we started to find solutions to reduce the pollution problem. "Biofabrication", also called the 4th industrial revolution, is one of the solutions we have found to reduce the dark side of fashion. Talking about fabrics made from natural materials is not a new innovation, however, talking about a new textile material that can be produced from living organisms naturally in biology laboratories, that represents an alternative for making garments and accessories, is a fairly new and groundbreaking innovation for the fashion world.

In the new generation society, where sustainability gains weight and where the "place of production" and the "quality" information on product labels are taken care of, as well as how and under what conditions they are produced, designs and designers have also adapted to the new era. Bio fashion products obtained from biotechnology have many features that will contribute to the environment, from cleaning with natural factors to being composted and disposed of in a harmless way.

The logic in biotechnology is to use living organisms to produce natural resources rather than just to consume them. In today's world, where the fashion world is the largest consumption source and the most polluting industry, the fabrics produced with biofabrication allow designers to raise awareness of this excessive consumption of natural resources and make people more responsive to the environment, in short, it aims to change one of the world's mostpolluting industry from the inside.

### Introduction

First of all, its name is not heard much nowadays; but it is a scientific invention, which is expected to become widespread in our future within 10 years, with the characteristics of the 4th industrial revolution. Despite the fact that it is a new technology since it was brought into the world before the end of 2000s. The term biofabrication was first used in 1994 to describe "biomineralization", a naturally occurring form of biofabrication (Fritz et al., 1994:49).

Mironov, predicting that biofabrication could significantly transform traditional production methods and resources in the future; He defined the term biofabrication as "the production of complex, living or non-living biological products consisting of raw materials such as living cells, molecules, extracellular matrices and biomaterials". Biofabrication continues to acquire prevalence because of least expensive gear and more proficient procedures. This mentioned technique is used not only in textile but also in health and it helps medical services in alternative ways, for example, by providing tools to aid sedative screening and drug remediation, paving the way for custom assembly strategies, 3D printing, more compelling drugs for damaged joints and organs. The main reason for the use of this technique in fashion is that the fashion industry is the most polluting industry in the world after the oil industry.

The fashion industry is the second largest polluter in the world just after the oil industry. And the environmental damage is increasing as the industry grows. accounting for 10% of global carbon emissions and 20% of industrial water pollution.

Charpail, M. (2017) What's Wrong With the Fashion Industry. Sustain Your Style. Available at: <u>https://www.sustainyourstyle.org/en/whats-wrong-with-the-fashion-industry</u> [20 November 2021].

The concept of sustainability, which has emerged with global warming and the decrease of natural resources, has triggered awareness about the consumption of products used in our daily life, and we can even say that "being sensitive" has become mandatory today. Now, it has become a necessity for almost all products in our environment to be produced ethically and be sustainable, thus, it has become necessary to design the effects of clothing, which is one of the products with the highest consumption rate among other sectors, on the environment as a whole, starting from the raw material, including the production process, until the end of its useful life. In this context, although "recycling" applications in the ready- made clothing industry are still more popular than bio-fabrication, the opinions that recycled products are not a long-term solution have gradually increased. For this reason, designers, scientists, researchers, and companies have turned to the search for environmentally friendly production models and material use as an alternative, starting from the harm of petroleum- based synthetic materials to nature. This mentioned technique, which was also called the "fourth industrial revolution", increased the interest in biodegradable materials and enabled the development and

diversification of methods that can be used in clothing production, and the widespread use of bio-fabrication in the fashion industry. Besides everything, it also offers us a wide overview of what can be done with biology applied to design while taking durability into account.

Unfortunately, it is known that the use of this epoch-making technique in the industry is still insufficient. Considering this inadequacy, the subject of study has been determined in order to introduce the types and production methods of bio-textiles that can be used in clothing production, to raise awareness and to contribute to their dissemination.

#### The Pollution Issue of The Fashion Industry

The fashion industry produces the world's 10% of CO2 emissions meanwhile the textile industry generates a large number of greenhouse gases due to the energy it uses for the production, manufacturing, and transport processes of millions of garments. In the other respects, falling clothing prices and overproduction of clothing allowed people to buy more clothing, resulting in more textile waste. The average number of clothes per person in the world now exceeds the number of clothes our grandparents owned.

In today's world, clothes have become something that is consumed and thrown away very quickly, so we are producing more and more textile waste. A family in Europe throws 30kg of clothes every year. Only 15% is recycled or donated the rest directly goes to landfill or is increnited. There's more than \$500 billion worth of textile waste every year, which comes from disposed of materials, under-used garments, and an absence of appropriate reusing measures. A new report by The Pulse Of The Fashion Industry expresses that fashion style adds to four percent of the universes yearly waste. In most of the textile producing countries, the textile factories dump their waste directly into rivers without any prior treatment.



Figure 1. European Parliament, EPRS (2019, 2020)

The water consumed to grow India's cotton exports in 2013 would be enough to supply 85% of the country's 1.24 billion people with 100 litres of water every day for a year. Meanwhile, more than 100 million people in India do not have access to safe water.

-Leahy, S. (2015). World Water Day: The Cost of Cotton In Water-challenged India. The Guardian. Available at: <u>https://www.theguardian.com/sustainable-business/2015/mar/20/cost-cotton-water-challenged-india-world-water-day</u> [20 November 2021].

On the other hand, in order to produce a t-shirt, it is necessary to consume as much water as a person's need of water for an average of 2.5 years. This valuable resource, which we lose day by day due to cotton production, which is the most important raw material of the textile industry, is getting smaller, and dramatic ecological consequences such as toxic chemicals from detergents poison rivers (Figure 2) and the desertification of the Aral Sea may occur. (Figure 3)



Figure 2. Toxic Foams of The Yamuna River, India, CNN



Figure 3. A comparison of the Aral Sea in 1989 (left) and 2014 (right), NASA

These contain poisonous substances like lead, mercury and arsenic among others all incredibly destructive to eco framework and individuals who live on the bank of streams. Pollution likewise reaches the entire ocean and then spreads to the planet.

#### How Can We Solve This Pollution and Why Do We Need Bio-Fabrication?

Humanity is faced with two main problems today; the first is the depletion of our precious natural resources nearby and the second is the increasing environmental problem with pollution. However, there are solutions and alternatives that nature offers us to reduce these problems. The first step is to develop awareness and a willingness to change, and then all we have to do is listen the living world, because it offers answers for us to find a solution to this problem, all we have to do is to observe and listen to the world and our environment.

The assets are decreasing quickly and regular strands, for example, cotton requires a significant number of them for handling. Oil-based manufactured filaments are not the most harmless to the ecosystem and the time has come to search for supportable, roundabout style options while creating strands and textures. About 60% of our clothing is made using artificially produced and non-biodegradable materials, but bio-fabrication involves making clothing using inheritably engineered organic assets and readily dissolves in soil within 30 days. To handle the issue of pollution, innovators have also adapted a biodegradable, practical, body-compatible product to the fashion industry.

Fashion designer Suzanne Lee talks about how using bacteria and fungi to make textiles will revolutionize manufacturing in her TED Talk speech. Bio-fabricated materials can be produced in a shorter time than conventional materials and consume fewer resources to manufacture, thus generating less waste and being biodegradable.

Instead of processing plants, animals or oil to make consumer materials, we might grow materials directly with living organisms. Bacteria, algae, fungi, yeast: our latest design tools include those of biotechnology.

Lee, S. (2019) Why "Bio-fabrication" Is the Next Industrial Revolution. TED Talks. Available at: https://www.ted.com/talks/suzanne\_lee\_why\_biofabrication\_is\_the\_next\_industrial\_r

evolution/transcript [17 August 2021].

Biofabrics materials incorporate materials developed from creatures like living microbes, green growth, yeast, creature cells, or organisms root structures. These organic entities can be developed in labs by taking care of them substrates, transforming them into 'natural fiber plants'. It likewise gives more noteworthy adaptability as the design, thickness, shading, and surface of the completed material can be modified into the DNA of the cells of the microorganism. As a little something extra point, biofabrics are the vegetarian option in contrast to false calfskins as they score better on supportability and furthermore kill the requirement for creatures at any stage. To explain the benefits of bio-fabrication in simple terms, it eliminates waste, it's sustainable, it eliminates traditional textile inputs like dyes, pigments, pesticides and water, can be produced faster than other garments, it's eco-friendly chemical and it's also bio-degradable.

We have to biofabricate our future. From the jacket we wear to the chair we sit on, all manufactured products should not compromise anyone's health or the sustainability of our planet. If materials cannot be recycled in nature or composted naturally, we should reject them.

#### **Through Bio-Fabrication Journey Growing garment process**

The point where sustainable fashion has come with biofabrication is now very advanced, a tennis dress can be produced from spider web (Figure 4) or a leather bag can be produced from mushroom. Products produced by biofabrication do not contain petroleum substances and can be biodegraded in the soil within 30 days, eliminating the slaughter of animals in their production, allowing the production of vegan leather, a more sustainable alternative to many artificial leathers currently on the market. In addition, no arable land is needed for the cultivation or cultivation of biofabrics, or pesticides or large amounts of chemicals and water are required for its processing.



Figure 4: The Adidas x Stella McCartney Biofabric Tennis Dress is made using Microsilk, dezeen.com

Biofabrication is harnessing the potential of such organisms as bacteria, yeast, algae, mycelium [the multi-celled fungus responsible for mushrooms] and mammalian cells to cultivate complex structures that can be processed afterward.

The United Nations, in 2018.

Fungi (mushrooms) are experts in destruction and transformation. Some types of mycelium have the power to digest toxins and turn these poisons into healthy energy. Mycelium can also break down plastic, destroying one of our most dangerous and toxic substances. For example, the fungus pestalotiopsis microspora can live entirely on polyurethane (the main component of plastic) and can even decompose plastics into new, safe fungal tissues.



Figure 5. Mycelium, ttbook.org

The thickness, color and texture of products produced by biofabrication can be programmed into the DNA of microorganism cells.

These microorganisms feed on substrates such as corn or sugar from algae and begin to multiply, turning them into biological fiber factories.



Figure 6. Necessary microorganisms for biofabrication, ted.com

The field of Biofabrication is employing all kinds of living organisms, from bacteria, yeast, fungi, algae and mammalian cells, to grow ingredients or materials for fashion. We can create leather-like materials using microbes that turn sugar into cellulose. If there is a living organism that can not only synthesise a material for you, but organise that into a finished structure, there are huge efficiencies to be gained there. There's no limit to the supply of microbes. Microbes will multiply so long as they are given sufficient nutrients to multiply.

Lee, S. (2019) Why "Bio-fabrication" Is the Next Industrial Revolution. TED Talks. Available at: https://www.ted.com/talks/suzanne\_lee\_why\_biofabrication\_is\_the\_next\_industrial\_r evolution/transcript [17 August 2021].

# **Bio-Fabricated Textiles and Dyeing**

Biofabricated products are inexhaustible, shut circle, and have an essentially more modest ecological impression than customary materials.



Figure 7. Algiknit, materialdriven.com

Biotextiles are only one strand of biofabricated materials, with numerous applications past the universe of style from bio-fabricated development materials to veggie lover meat substitutes developed from mycelium, with numerous biofabrication organizations offering a scope of materials to different industry areas. Also, it is not simply garments and textures which are being made thusly, yet colors as well. The structure, thickness, shading and surface of the completed material would all be able to be modified into the DNA of the cells of the microorganisms. These life forms are taken care of utilizing substrates, for example, sugar got from corn or green growth transforming them into organic fiber plants.

UK based Faber Futures, and Netherlands based TextileLab and Kukka are utilizing normally pigmented microscopic organisms to make compound free colors, which can be applied to both customary and biofabricated materials. Their living colour project is additionally take into account the chance of various shadings, which change the tone on request.

## Living colour project

They presented this project as an alternative to the toxic synthetic textile dyes that pollute the World. Living Color is a biodesign research project that explores the possibilities of natural textile dyeing with pigment-producing bacteria.



Figure 8. Natural textile dyeing with bacteria that produce pigment, livingcolour.eu

#### Mycoworks

The community of designers, engineers and scientists called MYCOWORKS, which produces leather from retaliation, has also produced a nature-friendly resilient leather that can be produced quickly and that does not use animals in its production. Since the material is a strong, flexible, durable and cultivated product, it can be produced in the desired pattern, texture, length and thickness. Since it is a biodegradable material, it does not harm the environment aswaste.



Figure 9. Vegan leather sample, mycoworks.com

#### Modern meadow

Zoa, by Modern Meadow is another biofabricated animal-free leather brand. Garments made from yeast-produced collagen protein derived from yeast. New properties such as patterning and lighter-weight options and a variety of textures and colours will also be available.



Figure 10. Vegan leather sample, Inc. Magazine

# AlgiKnit

Algiknit Inc., the LVMH Innovation Award 2018 Finalist, is a US-based company that produces yarn from Kelp. As with all this biofabrication technique, algae grows extremely fast and does not require any arable land to grow, and it also has the added benefit of sequestering carbon. It experiments with varying shapes, knit structures and naturally-dyed formats of their biomaterial, which is derived from abundant biopolymers.



Figure 11. Kelp (large Algae) are the source of Alginate, the biopolymer used by Algiknit to create their Bioyarn and bio-based textile, materialdriven.com



Figure 12: Seen here is AlgiKnit's transformation of their biomaterial from paste, to monofilament (yarn) and then a knit panel for bio-based textile, materialdriven.com

#### Spiber

Japanese company Spiber produces a protein fiber called Brewed Protein, based on the DNA used to produce spider silk. It is incredibly strong yet light and flexible, with all the ingredients that make it ideal for sportswear and technical applications. It is possible to imitate anything from protein, delicate filament fibers to leather and fur alternatives, as well as tortoiseshell and horn imitations.



Figure 13. Dress from spiderweb, thebridge.jp



Figure 14. Spiderweb yarn, spiber.jp

# MycoLab

Myco Lab, as they refer to themselves, is Australia's Leading Environmental Consulting and Laboratory specializing in environmental Mycology.



Figure 15. Vegan leather made out of fungal symbiotic complexe, animal free product (Natural colour), fungus-sapiens.com



Figure 16. Symbiotic complexe to replace cellophane or pliofilm, fungus-sapiens.com



Figure 17. Vegan leather made out of fungal symbiotic complexe, animal free product (naturally colored and engraved). Thinner than animal leather and more resistant, fungussapiens.com



Figure 18: Vegan leather made out of fungal symbiotic complexe, animal free product (naturally colored), fungus-sapiens.com



Figure 19. Vegan leather made out of fungal symbiotic complexe, animal freeproduct (naturally colored), fungus-sapiens.com

## The BioLace

In this Project, plants could be genetically engineered to produce both food and textiles at the same time, claims Carole Collet, researcher of innovative textile technologies and TFRC Deputy Director at Central Saint Martins College of Art and Design in London. Through her BioLace project, she biologically reprograms plants to produce both fruits and lace samples from their roots.



Figure 20. The plants are transformed into living machines that need only sun and water to operate, dezeen.com



Figure 21. Spinach roots, dezeen.com

# Le Qara

2019 Global Change Award Winner Le Qara is another lab-grown vegan leather alternative. Derived from microorganisms from flowers and fruits, it is breathable and biodegradable and can be made to mimic any skin texture and thickness.



Figure 22. Vegan leather bag, ucsm.edu.pe

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