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# Carole Collet

*Mycelium Textiles*

Name:
**Carole Collet**

Output Type:
**Artefact/other**

Output Title:
***Mycelium Textiles***

Date of Publication:
**2015 - 2019**

# Contents

# Project Overview

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Output type: Other

This output consists of 2 connected series of mycelium textiles prototypes, the first produced between 2015–2016 and the second 2018–2019.

**First series: 2015–2016:**
**From Earth, Mycelium Textiles**
Production of 30 mycelium textiles prototypes.

**First exhibited at:**
*+ultra. knowledge & gestaltung*, Martin-Gropius-Bau, Berlin, Germany, 30 September 2016–8 January 2017. An exhibition by the Excellence Cluster Image Knowledge Gestaltung. An Interdisciplinary Laboratory at the Humboldt-Universität, Berlin.

2 artefacts:
Mycelium Lace: d = 11 cm
Self-patterning myclelium rubber: d = 8 cm

Second series: Mycelium Textiles 2018–2019:
Production of 130 lab-grown mycelium textiles. A selection of the most successful prototypes were selected for several exhibitions as below:

**First exhibited at:**
*La Fabrique du Vivant*, Pompidou Centre, Paris, 20 January–4 March 2019

11 artefacts were exhibited as part of the exhibition.
Mycelium Textiles: 2 samples of mycelium pleats: 15 × 8 cm; 15 × 10 cm
Mycelium Textiles: 1 Tie-Grow sample: 20 × 20 cm
Mycelium Textiles: 2 Slow Grown Embroidery samples: 18 × 20 cm, 18 × 20 cm
Mycelium Textiles: 6 Lace Assemblies:
3 circular samples d: 20cm
3 trimming samples: 20 × 10 each

**Project Description**

*Mycelium Textiles* consists of two series of experimental textile design prototypes that explore the potential of bio-based mycelium techniques combined with textiles to develop new bio-integrated processes for sustainable textile fabrication and embellishment. Mycelium is the underground root system of fungi. By inducing a sterilised food substrate with mycelium liquid cultures or mycelium spawn it is possible to grow new materials exploiting the mycelium transformation of the food substrate into a material usable in a textile context.

Through design-led research, this project focuses on the compatibility of growing mycelium materials together with bio waste and textiles. It investigates the production of both soft and structural textile qualities by experimenting with the environment of growth of mycelium (food substrate, temperature and humidity), and the hybridisation of textile craft with mycelium processes to develop sustainable textile fabrication and embellishment techniques, testing protocols that encourage the dynamic property of a living organism to generate random patterns on textiles.

The first series consists of 30 samples including mycelium coating on lace (11 cm) and self patterning mycelium rubber (8 cm) →

that were developed alongside velvet-effect coating on silk chiffon, tartan patterning, embossing on silk. These protoptypes reinterpreted traditional textile craft such as mending, starching, coating and patterning with biological laboratory protocols and mycelium culture techniques, probing the possibility of adapting them to a new context of use where living mycelium cultures interact with inert textile materials.

The second series of mycelium textile prototypes is Informed by knowledge developed with the first series and includes 130 samples that specifically investigate the potential use of mycelium for permanent pleating of natural textiles at ambient temperature (currently not possible by other means), revisiting traditional resit textile technique such as tie dye, surface patterning and binding textile material to replace oil-based ‘bondaweb’. They include Mycelium Textiles: Pleats (five prototypes), Mycelium Textiles: Tie-Grow (two prototypes), Mycelium Textiles: Slow Grown Embroidery (two prototypes), Mycelium Textiles: Lace Assemblies (eight prototypes) – with dimensions ranging 20× 20 cm to 12 × 6 cm and 20 cm. They were produced and selected to be showcased for the first time at the *La Fabrique du Vivant* exhibition at the Pompidou Centre in Paris (2019).

Self-patterning mycelium rubber, prototype from the From Earth: Mycelium Textiles series one, Carole Collet 2016

Self-patterning mycelium rubber, prototype from the From Earth: Mycelium Textiles series one, Carole Collet 2016

Self-patterning mycelium rubber, prototype from the From Earth: Mycelium Textiles series one, Carole Collet 2016

Two outputs from the Mycelium Textiles: from earth series one exhibited *+ultra. knowledge & gestaltung*, Martin-Gropius-Bau, Germany, Berlin, 2016

Mycelium Lace, prototype from the From Earth Mycelium Textiles series one, Carole Collet 2016

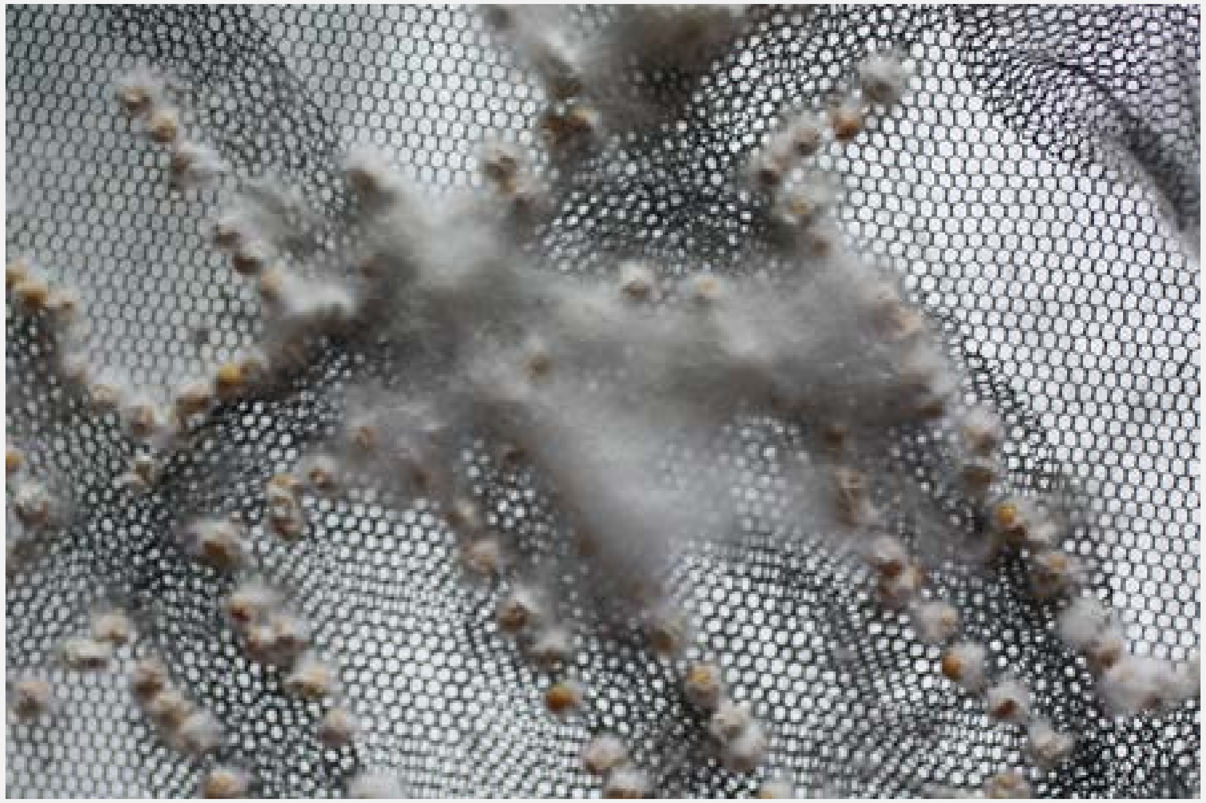
Mycelium Lace, prototype from the ‘From Earth: Mycelium Textiles series one, Carole Collet 2016

Mycelium Textiles: Pleats. Detail of mycelium growing on a circular pleated cotton organza

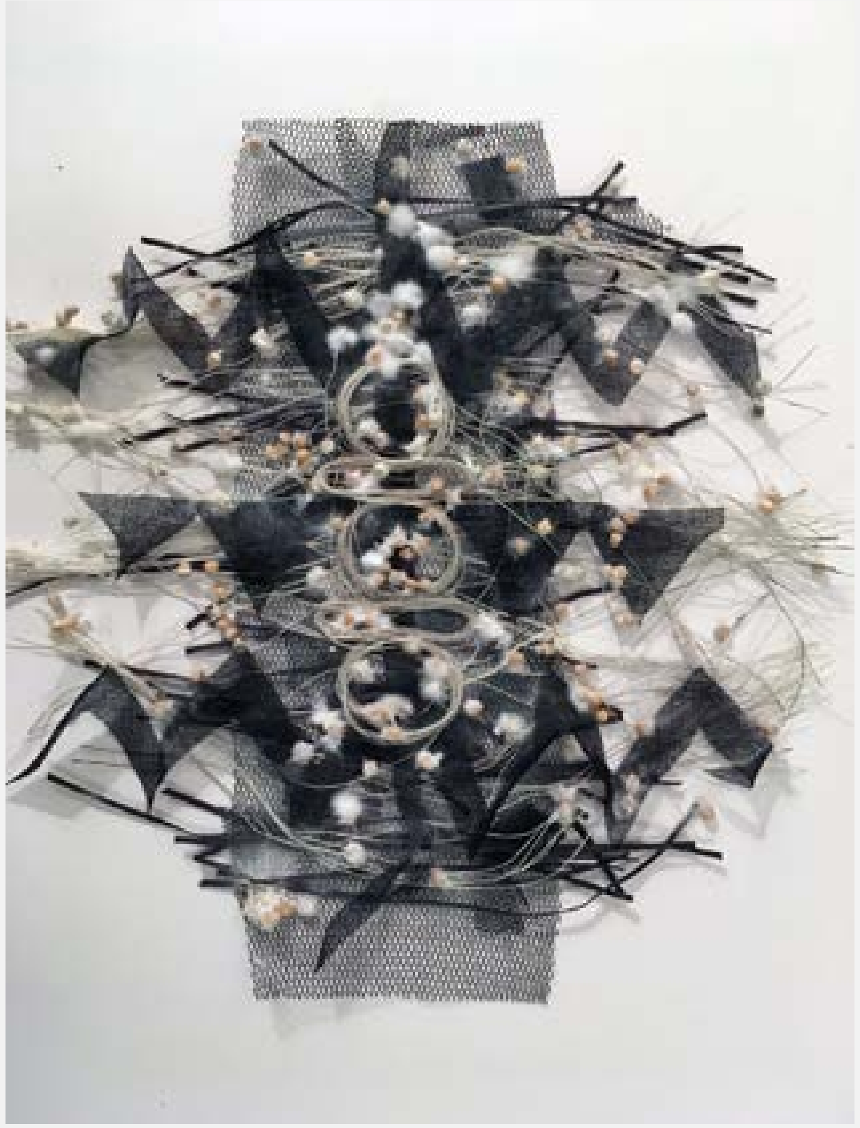
Mycelium Textiles: Tie-Grow, detail

Mycelium Textiles.Preparing selection of work for the Pompidou Centre centre exhibition *La Fabrique du Vivant*

Mycelium Textiles: Pleats. Example of an accordion pleats prototype



Mycelium Textiles: slow grown embroidery.
Detail of silk mesh fabric patterned with
mycelium during the growing phase



Mycelium Textiles: lace assemblies.
With this process, mycelium is used to
bind a range of fibres and fabrics together

Mycelium Textiles: lace assemblies:
Trimmings. A prototype where
mycelium binds together paper
yarns on a silk mesh base

Mycelium Textiles: lace assemblies: Doily

# Context & Questions

# Context

*Mycelium Textiles* is situated in the fields of biodesign (Myers, 2012), circular design (Webster, 2017) and sustainable textiles (Ellen McArthur Foundation 2017; Goldsworthy & Earley 2018) and is specifically concerned with designing textiles for the bioeconomy. The current textile industry
is acknowledged as one of the most polluting due to the environmental impact of fibre production and finishings such as coating, dying and printing (Ellen McArthur Foundation, 2017). This raises the questions of how to adapt the textile industry for a new sustainable bioeconomy, and how is it possible to evolve new bio-based processes that can capitalise on biological systems to develop alternative sustainable textile fabrication and patterning techniques.

Mycelium design research has gained prominence in the past decade with the work of pioneer artist Phil Ross. When this project started in 2015, mycelium research mainly focused on the production of hard biomaterials for insulation, packaging or 3D products (e.g. Phil Ross of Mycowork; Maurizio Montalti, Ecovative) including 3D printing with mycelium (Erik Klarenbeek).
In the Nederlands, Utrecht University (2015), the Material Experience Lab, TU Delft (2018) and designer Aniela Hoitink (MycoTex) were exploring the production of a flexible textile-like material made with mycelium grown onto a range of substrates such as agar as well as using textiles as a matrix and support for the growth of mycelium; but there was no published research into the use of mycelium as a patterning technique specifically used as alternative for sustainable textile embellishments.

Given the need to transition to circular models of production, mycelium materials provide an opportunity to use biowaste such as corn husks, saw dust, used coffee ground to grow mycelium cultures. By experimenting with waste textile materials applied to the growing mycelium material, *Mycelium Textiles* (first series) engages with the potential of mycelium to be used beyond the production of circular biomaterials towards the generation of textile bio-based embellishments. Specifically, this project →

questions concepts such as repair (mycelium lace - the mycelium grew over a hole in the fabric), and tests the compatibility of natural fabrics with diverse mycelium cultures to obtain a biomaterial and a patterned textile out of the same process. The multifunctional aspect of this mycelium cultivation protocol could lead to greater efficiency in the production of biomaterials.

Since the completion of the first mycelium textiles series in 2016, research into mycelium materials has further expanded with the development and commercialisation of new mycelium-made textile materials including the launch of the first mycelium leather by Mycoworks  (Phil Ross, 2017), followed by the launch of Milo™, a leather-like mycelium material developed by Bolt Thread in collaboration with Ecovative. Milo™ was used by Stella McCartney for a one-off Falabella bag showcased at the Victoria & Albert museum for the exhibition *Fashioned from Nature* (April 2018–January 2019).  In 2017 the exhibition *Fungal Futures* (2017, Universitetmuseum, Utrecht) curated by Maurizio Montalti showcased the expanding number of designers exploring mycelium to develop new making processes. In 2017, in collaboration with Ecovative, David Benjamin produced Hi Fi, the first large scale compostable temporary architecture for Moma PS1 in New York. Maurizio Montalti set up Mogu, an Italian-based mycelium manufacture and launched their first products: acoustic panels in 2019 (also exhibited for the first time at *La Fabrique du Vivant*, Pompidou Centre in 2019).  Ecovative and Mogu have now developed sponge like flexible mycelium materials. The last of the product launch is ‘madebyreiki’ by Mycoworks (2020), a new refined leather made with reiki cultures. These developments evidence how biodesign research in the field of mycelium can be upscaled into commercial initiatives, thus confirming the potential environmental impact of biodesign research. The second series of *Mycelium Textiles* engages with this expanding field  by focusing on establishing post-petrol textile fabrication and patterning processes, where biological agents replace current oil-based and/or energy-intensive processes.

## Questions

This biodesign research project asks:

Is it possible to integrate and control the living dynamic properties of mycelium into the textile design process? And can traditional textile craft know-how be combined with the production of mycelium material to develop new sustainable textile embellishment techniques for a post-petrol textile industry?

More specifically, is it possible to:

Use the production process of a mycelium-grown material to pattern a fabric, thus creating two outputs: a bio-based material, and a bio-patterned textiles out of the same process? →

Employ mycelium to create a permanent pleat on natural textiles at ambient temperature?

Replicate the traditional textile tie-dye process with mycelium?

Develop embroidery-like patterning effect onto natural textiles?

Use mycelium as a binding agent to assemble mixed textile materials in non-woven composites?

# Insights

# Insights

The two series of *Mycelium Textiles* offer different insights into potential alternative sustainable textile processes by adapting and reinterpreting mycelium material production techniques for textile embellishments.

In particular, the first series establishes that it is possible to generate textile embellishments with mycelium onto both cellulose and keratin based textiles. Furthermore, this series demonstrates that the by-product of the mycelium textile finishing process can be a hard biomaterial, thus achieving two outcomes out of one process: a hard biomaterial that could be used for insulation of packaging purpose, as well as a patterned fabric.

The self-patterning mycelium rubber offers further insight and is a unique example. This experiment was originally designed to test the growth of a mycelium culture onto used coffee ground, before combining it with a textile material. The mycelium culture colonised the coffee grounds by forming a flexible rubber-like material and no similar material have been published to date. In addition, the mycelium did not eat the coffee ground in four separate zones, thus leading to the appearance of fractal patterns reminiscent of floral designs. These patterns are the result of the behaviour of the mycelium itself, rather than being shaped by a mould. This demonstrates the potentials of the dynamic property of a living organism to create defined patterns.

The second series demonstrates that it is feasible to permanently pleat cotton at ambient temperature. Currently, it is only possible to produce permanent pleats on a synthetic fibre (such as polyester) which is heat-set at high temperature to form the pleated pattern. Once cooled the material will keep the pleats, even when washed. For a natural fabric such as cotton, heat can be used to set a pleated pattern, but once washed the pleats disappear and are therefore not permanent. In *Mycelium Textiles: Pleats*, mycelium was grown over a mechanically pleated cotton at ambient temperature. Once the mycelium created a fine layer over the pleats, the sample was →

baked at low temperature (40°C), and the pleats were fixed in position and remained even when hand-washed.

This series also offers a reinterpretation of a tie-dye technique with mycelium. *The Mycelium Textiles Tie-Grow* samples revisit the principles of tieing a cloth before to die it. The removal of the ties reveasl the original colour of the material, where the dye could not reach. The same techniques has been applied here to achieve a tie-dye aesthetic with mycelium coating which has water repellent properties inherent to mycelium.

In this series mycelium was also used in relation to other patterning techniques and binding. One of the main challenge when using mycelium to pattern fabric is the control of its growth to create defined patterns. By precisely containing the location of the food substrate underneath/ above the fabric it is possible to either encourage or stop mycelium growth thus creating a chosen pattern. For Mycelium Textiles: Slow Grown Embroidery, such technique was pushed to the extreme to create the effect of small dots/stiches.

The *Mycelium Textiles Lace Assemblies* prototypes further showcase the use of mycelium as a bio-based binding agent to create composite structures, in this case made from mixed textile materials.

# Methods

# Methods

Mycelium is effectively the root system of fungi. It naturally lives on our soils but can also grow in controlled environments on a wide rande of food substrates.

The basic protocol for the production of mycelium-based material consists in using a sterilised wet cellulosic based material as a food source for the mycelium (such as saw dust, corn husks left over from corn farming, waste coffee grounds). The food source is inoculated with a mycelium culture in a sterile environment, using a mould as a container to shape the material. The mycelium grows and digests the food source turning it into a naturally bio-processed material. The temperature and humidity levels are set according to the chosen mycelium culture and generally ranges from 18–24°C. Once the mycelium has processed all the food, the material is baked at low temperature (50–60°C) to kill the live mycelium culture and render the biomaterial inert. This protocol can take from five to 22 days depending on the size of the mould, the food source, as well as the culture and temperature used.

This basic protocol has been revisited and reinterpreted in order to achieve bio-based textile patterning and embellishing effects of *Mycelium Textiles*. This has been attained through an iterative material-based methodology whereby by recording failed and successful experiments, protocols are adjusted to refine the process until a final result is achieved. The success criteria is determined by what the experiment was set out to achieve (i.e. a coating, repairing, creating a tie-dye effect, binding fibres). However, the nature of working with a dynamic living organism makes the role of the designer becomes one of guiding and controlling the growth of the organism, using diet control, temperature variation as well as resist techniques to achieve a range of processes relevant to textiles.

This methodology entails the following:

**Laboratory**

The work is produced in a DIY laboratory and each experiment is documented in laboratory record sheets and photographically.

**Sourcing, tools and materials:**

Food source used in this research is cellulose-based and sourced from waste, as well as from mycelium suppliers. This include waste coffee ground collected from coffee shops, saw dust and rye grains. In series one, the research focused on testing a range of mycelium cultures on different food subrates and with different types of natural textiles such as cotton, hemp, linen, silk, vintage lace, lace-off cuts.

**Setting up experiments:**

Each experiment comprises five repeatable phases:

Step 1: plan the experiment and select the container, food sourse, textile material.

Step 2: sterelise the food source, textile samples and tools (such as spoons) in a pressure cooker.

Step 3: work under a laminar hood (a clean air environment that helps prevent →

contamination): place food into a chosen petri dish/a clean container, or onto a clean surface. Innoculate the food with a mycelium culture, then place the textile on top of the food. By mixing different types of food and by creatively positioning the fabrics, a wide range of results and many iterations can be obtain with the same ingredients.

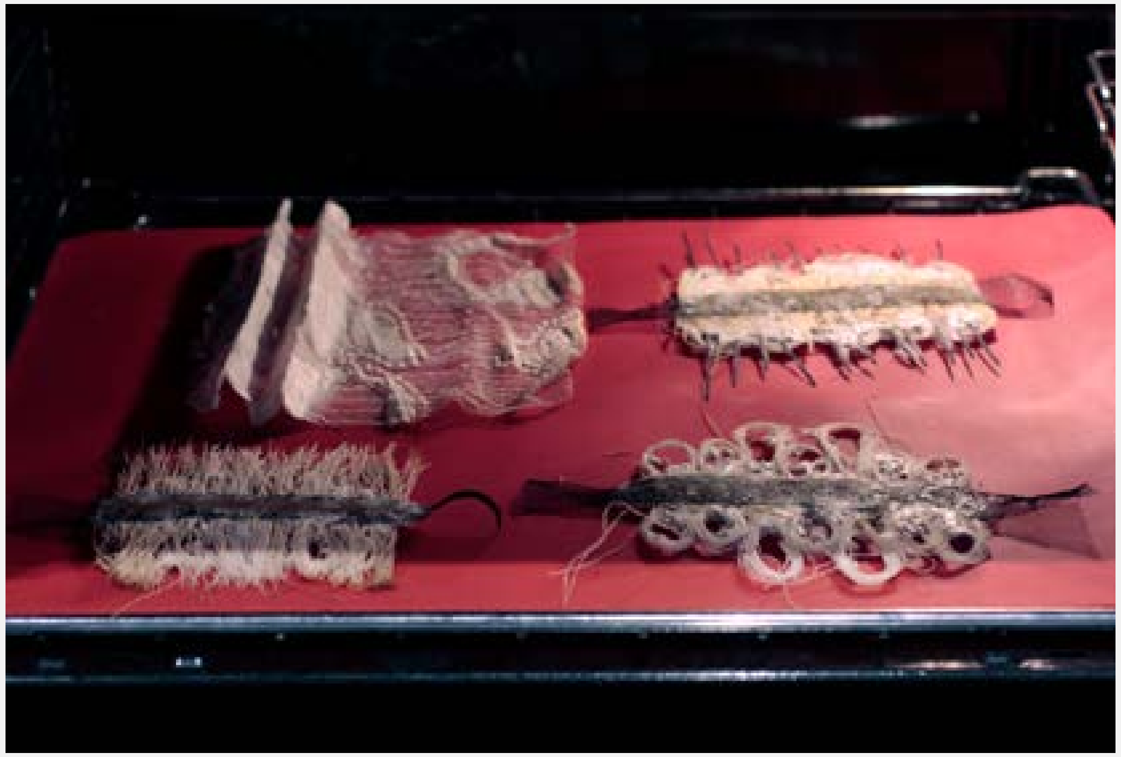
Step 4: seal the container in a clean plastic bag to prevent contamination and place ona shelf to grow. The tempereature of growth is selected according to the optimum growth temperature of the chosen mycelium culture. The duration of the experiment also varies depending on the size of the fabric/ container. For *Mycelium Textiles*, the shortest growth time was five days and the longest was 22 days.

Step 5: Growth and harvest. The progress of mycelium growth is monitored through the clear plastic bag or the petri dish. The fabric sample is then separated from the base mycelium material and baked at low temperature. Here tempereature range from 40 to 60°C, and from 30 minutes to two hours depending on the size and thickness of the sample. This process kills the live culture

of mycelium and renders the fabric sample inert. It is then washed and cleaned where appropriate.

Selection of some of the materials
used for Mycelium Textiles series two

Inoculation of a sterilised food substrate with a liquid mycelium culture. The black cotton organza is placed on top of the saw dust before to close the petri dish with the lid



Baking the samples in an oven to kill mycelium and obtain a biologically inert material

Mycelium Textiles: slow-grown embroidery.
Mycelium growing on a silk mesh.
Photography Immatters

Mycelium Textiles: Tye-Grow
samples – growing in progress.
Photography Immatters

Mycelium Textiles: Mycelium lace- first experiment which combines the growing of a hard material with the patterning and mending of a lace fabric.

# Dissemination

# Dissemination

**Exhibitions**

Collet, C. (2019) 'Elements of first mycelium prototypes', *La Fabrique du Vivant*, Pompidou Centre, Paris. 20 January–4 March.

Collet, C. (2019) 'Elements of second mycelium prototypes', *Saint Etienne Design Biennale: 'Me, You, Nous: Designing Common Grounds'*, Saint Etienne. 21 March–22 April. Video link.

Collet, C. (2019) 'Elements of second mycelium prototypes', *SynbiTECH 2019*, Queen Elizabeth II Centre, London. 24–25 June.

**Public talks, demonstrations and keynotes about the research**

Collet, C. (2017) 'Exploring Transient Territories for Biodesign: Design & Living Systems Lab', *RGS-IBG Annual International Conference 2017*, Royal Geographical Society, London. 29 August–1 October.

Collet, C. (2017) 'Grow-Made: Emergent biofabrication tools and practices', *Make-Shift Ireland Conference*, The Helix, Dublin. 6 November.

Collet, C. (2018) 'Radical Matter' [Presentation and Panel Discussion], *Book Launch: Radical Matter* (K.Franklin and C.Till, Thames and Hudson), Design Museum, London. 13 March.

Collet, C. (2018) 'Luxury and the New Natural: How designing with living systems can lead to disruptive models of production for the luxury sector', *Fashion Colloquium: Searching for the New Luxury*, ArteZ, Arnhem, The Netherlands. 31 April–1 June.

Collet, C. (2018) 'Recalibrating Fashion and Textiles for the Emerging Bio-circular Economy', *Fashion Tech Talk Conference*, Stockholm. 6 June.

Collet, C. (2018) 'Biodesign as a Catalyst for Sustainable Innovation', *Bio Meets Digital Symposium*, Atelier Neerlandais, Paris. 22 June.

Collet, C. (2018) 'Biodesign: pour une mode ecologique', *Design Marabout n6 Symposium*, Pompidou Centre, Paris. 12 December.

Collet, C. (2019) 'Pour une Bio Ecologie du Design', *Saint Etienne Design Biennale Conference, Terrains d Entente: l'Homme, la biologie et l'IA*. 21 March.

Collet, C. (2019) 'Design and Living Systems Lab' [Keynote], *Human Nature Conference, Ax Foundation*, Stockholm. 9 April.

Collet, C. (2019) 'Biotextiles: towards a post-petrol era?', *Design with the Living Symposium* [co-curator], Design Museum, London. 11 December.

**Catalogue essay:**

Collet, C. (2019) 'Le Biodesign, un cataliseur d'innovation ecologique pour l 'industrie textile?', in Brayer, M.A. and Zeitoun, O. (eds)., *La Fabrique du Vivant, Mutations Creations*. Paris: Pompidou Centre and Hyxx publishings, pp.117–128.

**Peer-reviewed conference and proceedings:**
Collet, C. (2017) ‘Grow-made Textiles’, in Karana, E., Giaccardi, E., Nimkulrat, N., Niedderer, K. & Camere, S. (eds.), *Alive. Active. Adaptive. Proceedings of International Conference 2015 of the Design Research Society Special Interest Group on Experiential Knowledge (EKSIG 2017)*. Delft, The Netherlands: Delft University of Technology, pp. 24–37.

**Citations of research in books:**
Franklin, K. and Till, C. (2018) *Radical Matter*. London: Thames & Hudson.

Gallot, G. (2020) *Design Durable*. Paris: Éditions de la Martinière.

**Reviews, features and press**
Franklintill (2018) ‘Living Materials’, June. Available at: https://www.franklintill.com/journal/living-materials (Accessed: 11 February 2021).

Ray, D. (2019) ‘In London as researcher guides biodesign into uncharted and newly relevant territory’, *Metropolis Magazine*, 4 September.

Snoad, L. (2019) ‘Growing Fashion’, *Crafts*, 280 (September/October), pp. 28–37.

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