

CO-CULTIVATING COLOURS

An experimental driven textile design approach to understand microbial colourants for textile design in craft, education and industry

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PhD Defence Brief

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Summary

This dissertation presents the findings from the PhD project titled “Co-Cultivating Colours”. The aim of the project has been to explore how textile designers can work with microbial colourants across three contexts: textile design craft practice, textile design education practice, and textile design practice for industrial application. Additionally, the project investigates how microbial colourants expand the roles of textile designers.

The dissertation is the outcome of an experimental and practice-based PhD project. Experimental activities have been central to the research process, and the contributions from the project reflect this focus. The knowledge contributions are divided into two perspectives: textile design practice and method development.

Contributions for textile design practice

The dissertation contributes to the following four areas:

- **Textile design craft practice:** An exploration of how microbial colourants can be utilised in a DIY biolab setting. The results revealed that all the colourants faded significantly, albeit to varying degrees. Fading was explored as a design quality to understand how the colourants faded.
- **Textile design education practice:** Insights into how various sensuous approaches have been used as methods to integrate microbial colourants into design education. The results demonstrated that tools and workshops could be applied to incorporate microbial colours.
- **Textile design practice for industrial application:** An understanding of the performance of microbial colourants in relation to conventional colour fastness tests, alongside efforts to optimise light fastness using different materials and technologies. The results indicated that the light fastness of the colourants remains a challenge.
- **Textile designer roles:** An exploration of how knowledge, skills, and competences are applied across multiple textile biodesigner roles. The outcome has been consolidated into a tool named “Biodesigner Roles Cards”.

Photo credits for Contemporary Colour Demonstrators: Ruth Lloyd (left), Monica Hartvigsen (middle), Mikko Raskinen (right).

Practical outcomes for textile design practice

The practical outcomes provide tangible representations of research results.

Contemporary Colour Demonstrators:



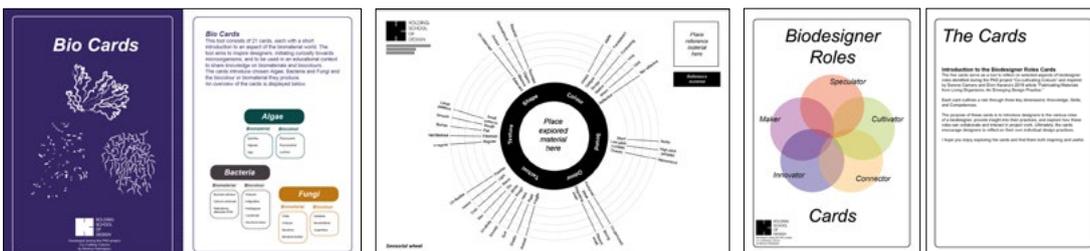
Physical Material Samples:



A Biolab Booklet and DIY Biolab:



Bio Cards, Sensuous Tool and Biodesigner Roles Cards:



Contributions for method development

The methodology for this project has been structured around trinities: three research contexts, three research domains, and three research approaches. This framework has enabled the research to maintain a non-linear, dynamic, and flexible process.

From this methodology, the following concrete contributions have emerged:

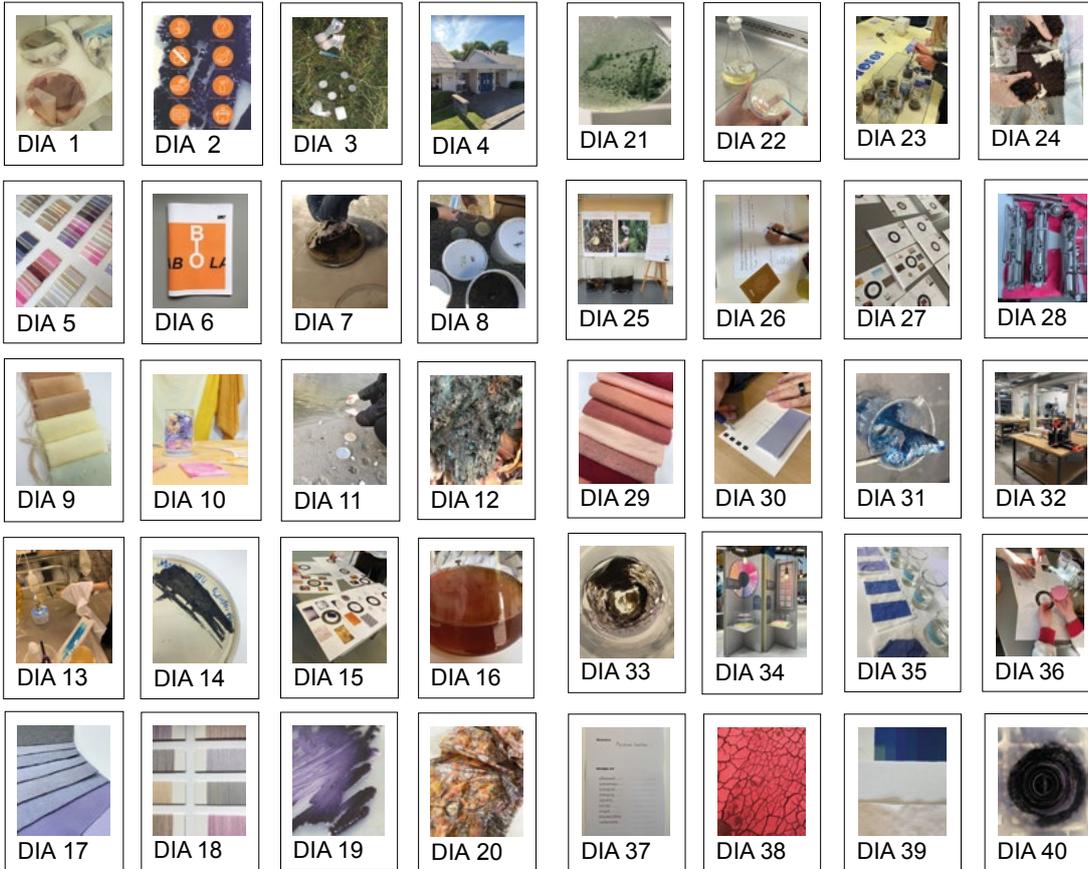
- ◆ **Dialogues (DIA):** The **DIA**'s have been developed as a concept to structure and analyse the experimental activities, providing a systematic approach to organising the research process.
- ◆ **Dialogue Cards:** The Dialogue Cards have facilitated the unfolding of the research and the generation of insights. They have been particularly useful for recalling experimental activities, especially during the writing process. Additionally, the Dialogue Cards have guided the analysis of experiments across the three research contexts.
- ◆ **The Orbital-Particle Model:** This model illustrates how design researchers can engage in practice-based design research. It serves as a bridge between multiple research contexts, connecting academia and industry.

This dissertation is intended for students, designers, educators, and researchers interested in exploring microbial colourants from a textile design perspective. It is also relevant to adjacent disciplines such as fashion design, industrial design, materials science, engineering, and design anthropology.

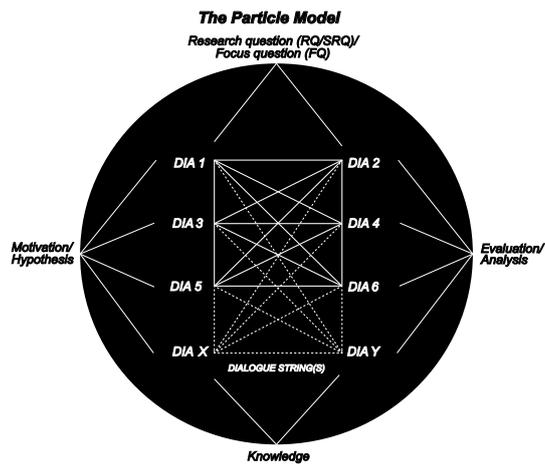
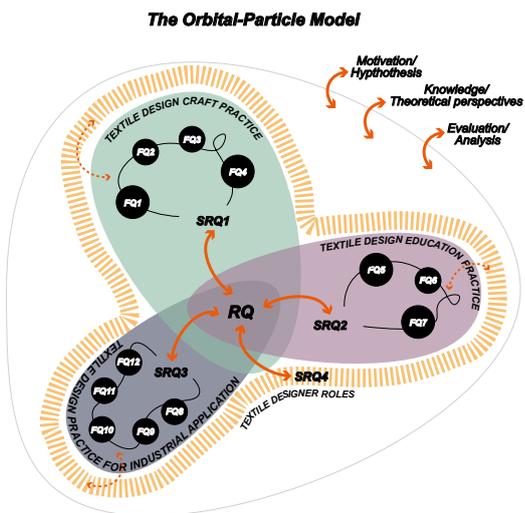
It is my hope that readers will find inspiration in this project and utilise its practical outcomes to further advance this research area.

Practical outcomes for method development

Dialogue Cards:



The Orbital-Particle Model:





How to read the dissertation

The PhD project is disseminated by a written dissertation consisting of nine chapters compiled as the main book. In addition, four appendices accompany the dissertation, compiled into a separate book.

The project has been conducted as constructive design research, with experimental activities and practical work central to developing knowledge on microbial colourants from a textile design practitioner's perspective.

The research has unfolded through an iterative process, combining practical work with theory across the three textile design practice contexts: craft, education, and industrial application. The dissertation reflects this structure by organising the chapters according to the context explored.

The nine chapters are colour-coded, each applying a distinct colourway to provide a visual overview and aid navigation through the main chapters. These chapters are outlined below:

-  Chapter 1: Introduction, research context and theory
-  Chapter 2: Contemporary Colour Demonstrators
-  Chapter 3: Research methodology
-  Chapter 4: Microbial colours in textile design craft practice
-  Chapter 5: Microbial colours in textile design education practice
-  Chapter 6: Microbial colours in textile design practice for industrial application
-  Chapter 7: Discussion of insights and implications
-  Chapter 8: Textile designer roles emerging from microbial colours
-  Chapter 9: Conclusion and reflection



Chapter 1: Introduction, research context and theory, explains the research context and introduces the biodesign research field, which is the foundation for this project.

Chapter 2: Contemporary Colour Demonstrators, presents selected “Contemporary Colour Demonstrators” working with microbial colours, spanning design research, industrial application research, education research, and commercial application.

Chapter 3: Research methodology, details the research methodology, positioning the project within practice based design research. It explains how the design experiments are used to answer the research questions by developing the design tool “Dialogue Cards” and clustering them into “Dialogue Strings”. The chapter also describes the analysis of these clusters, leading to findings and insights.

The three following chapters present the findings from the design experiments or “Dialogues Strings” explored in the three research contexts. Chapter 4: Microbial colours in textile design craft practice, explains the findings from the Dialogue Strings exploring textile design craft practice. Chapter 5: Microbial colours in textile design education practice, explains the findings from the Dialogue Strings exploring textile design education practice. Chapter 6: Microbial colours in textile design practice for industrial application, explains the findings from the Dialogue Strings exploring textile design practice for industrial application.

Chapter 7: Discussion of insights and implications, discusses the findings from the three previous chapters. The findings leading to insights are discussed through three topics: microbial colour performance, microbial colour implementation and microbial colour ethics.

Chapter 8: Textile designer roles emerging from microbial colours, unfolds the meta-findings related to textile designer roles, which have emerged from the experimental activities in the Dialogue Strings.

Chapter 9: Conclusion and reflection, summarises the knowledge contributions of the project, focusing on microbial colours from a textile designer perspective and method development. It also presents the practical outcomes and concludes with suggestions for future research directions.

Accompanying this dissertation are four appendices compiled into one file. Appendix 4 contains one booklet and three tools, which can be downloaded as separate PDFs.

- Appendix 1: Dialogue files
- Appendix 2: Contemporary Colour Demonstrators
- Appendix 3: Article and papers
- Appendix 4: Booklet and educational tools
 - Biolab Booklet (download at: <https://monicahartvigsen.com/biolab-booklet/>)
 - Bio Cards (download at: <https://monicahartvigsen.com/bio-cards/>)
 - Sensuous Tool (download at: <https://monicahartvigsen.com/sensuous-tool/>)
 - Biodesigner Roles Cards (download at: <https://monicahartvigsen.com/biodesigner-roles-cards/>)

Throughout the dissertation, the project is primarily narrated using a passive voice to maintain an objective and neutral tone. However, when it is necessary to convey personal experiences and reflections, an active voice is used through the first person.

Unless otherwise indicated, all photos and visualisations in this dissertation have been taken or drawn by me.

The dissertation exists in both digital and printed formats. It is recommended to read the digital version as a two-page spread to experience the layout as intended. If the digital version is not opened as a two-page spread, this can be adjusted in Adobe Acrobat by navigating to View → Page display → Two page scrolling.

Dissemination

Selected elements of the experimental activities have been disseminated to various audiences through different media, as outlined in Table 1, Table 2 and Table 3. The dissemination has been developed as part of the PhD project but also includes findings from the master's thesis project, titled "Bacteria Dye – The Pigment of the Future".

In "Book contribution 1" the master's thesis project and the initial stages of this PhD project are presented in: "Climate: Building Resilience in the Era of Climate Change".

"Exhibition 1" and "Exhibition 2" showcased microbial coloured textile samples from the project to a public audience. "Exhibition 3" has displayed the outcome of a speculative workshop held at "Klimafolkemødet Middelfart", and has thereafter been exhibited at DSKD.

"Journal article 1" disseminates the practical work conducted during the master's thesis project. "Conference paper 1", "Conference paper 2" and "Conference paper 4" explore implementation of microbial materials and colourants in design education, while "Conference paper 3" explores implementation of biobased colourants for small to medium sized companies (SMC).

"Education activities" encompass the courses I have been a part of, as an educator, during the PhD study.

Additional dissemination	
Book contribution 1	Hartvigsen, M. (2021). Bacteria Dye. In K. Lindhardt Weiss & S. Jønker Johnsen (Eds.), <i>Climate: Building Resilience in the Era of Climate Change</i> (pp. 60–63). Arkitektens Forlag.
Exhibition 1	BioColour - Exploring sustainable colour (14th of October to 5th of December 2021). Arktikum, Rovaniemi, Finland. Link to museum: https://arktikum.fi/en/
Exhibition 2	Bacterial colouring (20th of April 2023 to 30th of April 2024). Danish Technical Museum, Helsingør, Denmark. Link to museum: https://tekniskmuseum.dk
Exhibition 3	Speculative soil at Klimafolkemødet, Middelfart, Denmark (2nd of September to 18th of October 2022) and DSKD, Kolding, Denmark. Link to Klimafolkemødet: https://klimafolkemoedet.dk/ and link to school: https://www.designskolenkolding.dk/en

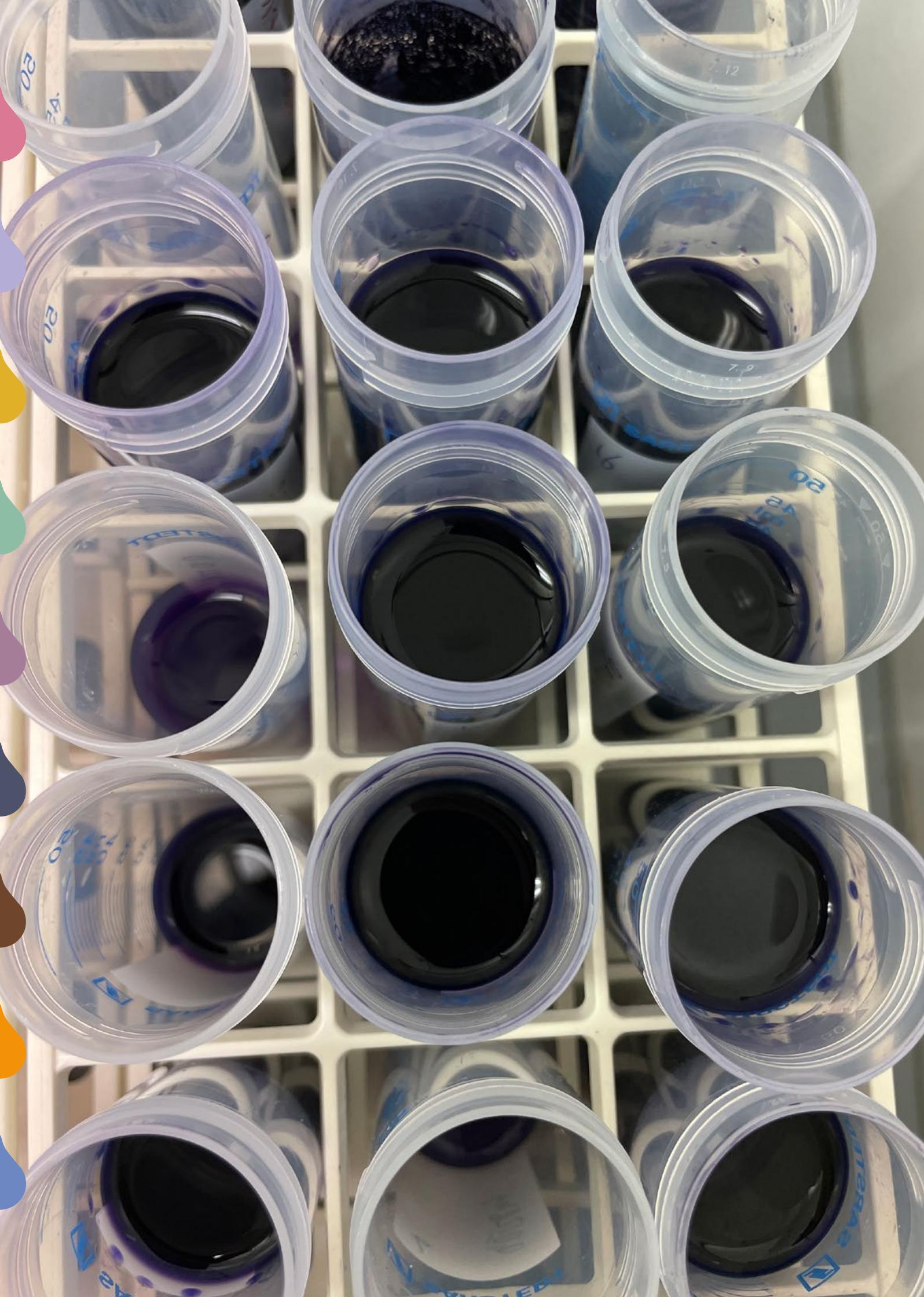
Table 1 Overview of additional dissemination.

Peer-reviewed	
Journal article 1	Hartvigsen, M. L. G., & Rees, V. E. (2022). Bacterial colouring: Using multi-disciplinary methods for ecofriendly textile design. <i>Journal of the International Colour Association</i> , 30, 10-23. https://aic-color.org/journal-issues
Conference paper 1	Hartvigsen, M. L. G., Otersen, S., & Hasling, K. M. (2023, June 19-20). <i>Designers prototyping in the lab: Introducing an extracurricular activity exploring bacterial colouring in a design educational setting</i> . Design Research Society Special Interest Group on Experiential Knowledge (EKSIG), Milan, Italy. https://www.researchgate.net/publication/375520054_Designers_prototyping_in_the_lab_Introducing_an_extracurricular_activity_exploring_bacterial_colouring_in_a_design_educational_setting
Conference paper 2	Hartvigsen, M., & Hasling, K. M. (2022, September 8-9). <i>EXPLORING SENSUOUS QUALITIES OF TEXTILES</i> . DS 117: Proceedings of the 24th International Conference on Engineering and Product Design Education (E&PDE 2022), London South Bank University in London, UK. https://doi.org/10.35199/EPDE.2022.25
Conference paper 3	Hartvigsen, M., & Permiin, L. (2023, May 31-June 2). <i>Futuring alternative biobased colour systems - testing possibilities of fading and redyeing with (SMC) Danish lifestyle companies</i> . Proceedings of the 5th International PLATE Conference (PLATE 2023), Espoo, Finland. https://www.plateconference.org/call-for-contributions-2/
Conference paper 4	Hartvigsen, M. (2023, September 7-8). <i>THE BIOMATERIALS SPECTRUM - exploring emerging pathways for textile design education</i> . FUTURESCAN, University of Leeds, UK. https://doi.org/10.6084/m9.figshare.23751027.v1

Table 2 Overview of peer-reviewed articles and papers.

Education activities		
When?	What?	Who?
18th of January to 12th of February 2021	Material Strategies, BA3,	3rd year undergraduate students from accessory, industrial and textile design (approximately 30 students). Link to course information: https://www.designskolenkolding.dk/en/study-at-the-school/bachelor
30th of August to 15th of October 2021	Material Narratives, MA1	1st year Design for Planet postgraduate students (approximately 30 students). Link to course information: https://www.designskolenkolding.dk/en/line-of-study/planet
17th of January to 11th of February 2022	Material Strategies, BA3	3rd year undergraduate students from accessory, industrial and textile design (approximately 30 students). Link to course information: https://www.designskolenkolding.dk/en/study-at-the-school/bachelor
29th of August to 14th of October 2022	Material Narratives, MA1	1st year Design for Planet postgraduate students (approximately 30 students). Link to course information: https://www.designskolenkolding.dk/en/line-of-study/planet
15th, 20th and 27th of September 2022.	Extra curricular: Bacterium colour workshops (three hours)	Two groups of seven interested undergraduate and postgraduate students from DSKD
23th of January to 17th of February 2023	Material Strategies BA3, course responsible	3rd year undergraduate students from accessory, industrial and textile design (approximately 30 students). Link to course information: https://www.designskolenkolding.dk/en/study-at-the-school/bachelor

Table 3 Overview of educational activities.



Practical outcomes

In this section the following practical outcomes are gathered and presented to inspire the reader to apply the outcomes.

- Contemporary Colour Demonstrators
- Physical Material Samples
- A Biolab Booklet to support the DIY Biolab
- The Bio Cards, the Sensuous Tool and The Biodesigner Roles Cards

Contemporary Colour Demonstrators

Form: Tables of demonstrators with references in a PDF found in Appendix 2.

This resource brings together examples of researchers, inventors, educators, and companies working within the field of biocolours. The demonstrators highlight how the research area has developed and where knowledge gaps remain. As the field of biocolours is rapidly growing, additional examples can continuously be added.

The colour demonstrators can serve knowledge such as:

- 💧 Craft practitioners can be inspired by the demonstrators. It could also serve as a library of possible collaborators.
- 💧 Design students can be inspired by the demonstrators and use them as a starting point for their own design projects.
- 💧 Industrial partners can gain insights into the development of the biocolour field and identify demonstrators for potential collaboration.

The demonstrators are categorised into four groups and examples of these can found in Figures 1 to 4.



Figure 1 Design Research Demonstrators: Ruth Lloyd - Bacterial screen printing workshop (https://www.instagram.com/p/CdgjzXUNSXy/?img_index=1) (left) and Charlotte Werth - Bacterial Dye Machine_01 (<https://charlottewerth.com>) (right).



Figure 2 Industry Directed Research Demonstrator: Supercritical CO₂ dyeing at Högskolan Borås (DIA 28).



Figure 3 Educational Demonstrator: CHEMARTS course. Photo credit: Mikko Raskinen (Niinimäki et al., 2018, p. 64).



Figure 4 Commercial Application Demonstrator: Apparel from Pangaia (<https://colorifix.com/colorifix-x-pangaia-lab-launch/>).

Physical Material Samples

Form: A collection of physical samples, documented with photographs, used for colour performance testing, shown in the Dialogue Archive in Appendix 1.

Material samples of textile materials coloured with microbial colourants, including effects of exposure to light.

The material samples can serve knowledge such as:

- 💧 Craft practitioners can be inspired to develop their own material samples and explore techniques possible in a DIY setting.
- 💧 Educators and design students can be inspired to develop their own material samples and explore techniques. Educators can also use the samples as part of a course to educate students in biodesign.
- 💧 The industry context can use the results to understand the potential of microbial colourants.

Figure 5 exemplifies materials coloured with microbial colourants, created in an educational context in collaboration with students.



Figure 5 Materials samples from the educational context (DIA 23).

Figure 6 and Figure 7 exemplifies textile materials coloured with microbial colourants, including effects of exposure to light.



Figure 6 Materials samples of textiles coloured with microbial colourants (DIA 5).



Figure 7 Materials samples of textiles coloured with microbial colourants, showing the effect of exposure to light (left) (DIA 18) and PP melt spun with violacein (right) (DIA 40).

The DIY Biolab and a Biolab Booklet

Form: A PDF with photos and links to video explanations, available at: <https://monicahartvigsen.com/biolab-booklet/>.

It documents how the DIY Biolab, Figure 8, was established at DSKD and provides guidance for working in the space. The biolab was created to support interested students and assist in craft practice experiments involving biodesign.

The booklet can serve knowledge such as:

- 💧 Craft practitioners can use the booklet as inspiration to establish their own DIY biolab or to test recipes in an existing biolab.
- 💧 Design students can learn how to navigate safely in a biolab, explore techniques and processes, and grow materials and colours for their projects.
- 💧 Inspire industrial partners to gain insights into setting up a small-scale DIY biolab for pilot testing in R&D projects or apply the recipes in development processes.

Figure 9 is a spread from the Biolab Booklet.



Figure 8 The DIY Biolab at DSKD (DIA 1).

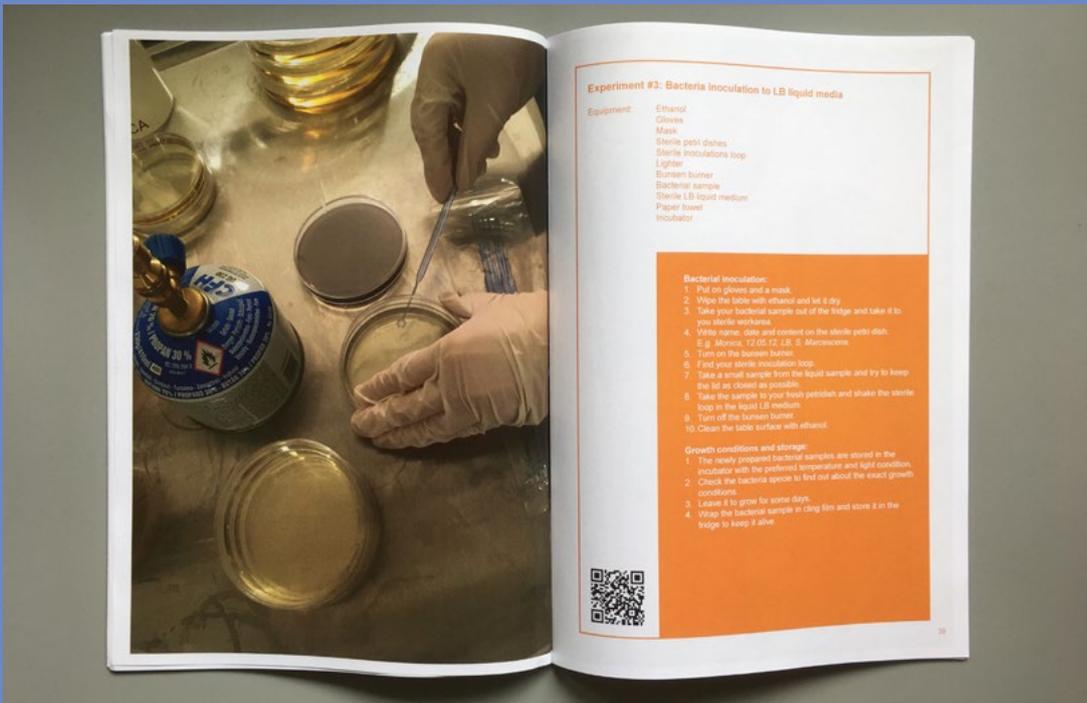


Figure 9 A spread from the Biolab Booklet (DIA 6).

Educational tools

Form: Three PDFs each containing a tool, with descriptions on how to apply them.

This project has developed a series of educational tools designed to inspire and support designers, students, and industrial partners in exploring biodesign, biomaterials, and microbial colourants.

- 💧 **The Bio Cards:** <https://monicahartvigsen.com/bio-cards/>.
- 💧 **The Sensuous Tool:** <https://monicahartvigsen.com/sensuous-tool/>.
- 💧 **The Biodesigner Roles Cards:** <https://monicahartvigsen.com/biodesigner-roles-cards/>.

These tools are available as downloadable resources and serve as practical outcomes of the research.

- 💧 Craft practitioners can use the tools to understand microorganisms and materials, develop new designs, and communicate material qualities and roles with collaborators or clients.
- 💧 Design students are encouraged to explore biomaterials, develop a language for sensuous material qualities, and reflect on or specialise in biodesigner roles as part of their education.
- 💧 Industrial partners can gain inspiration for research and development, communicate material qualities effectively, and identify the roles needed for successful interdisciplinary biodesign projects.

Figure 10 shows examples from the Bio Cards tool, Figure 11 shows two of the three wheels from the Sensuous Tool and Figure 12 shows examples from The Biodesigner Roles Cards.

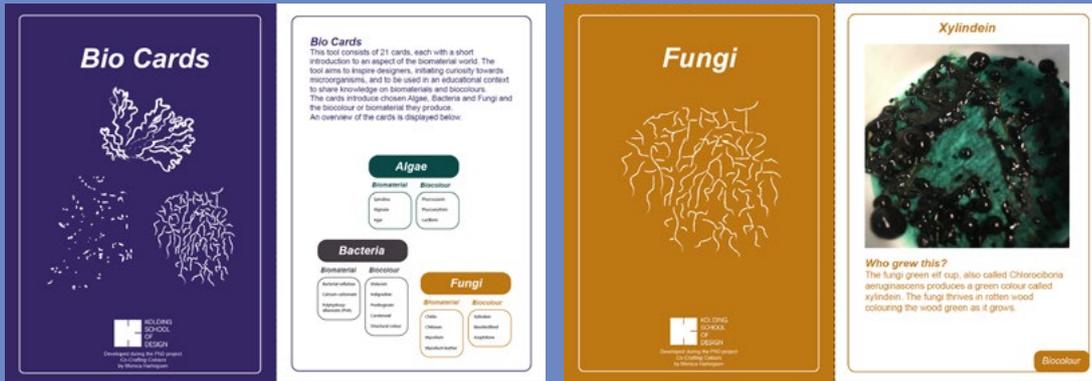


Figure 10 Examples of Bio Cards (DIA 26).



Figure 11 The sensorial wheel and the impact wheel from the Sensuous Tool (DIA 36).

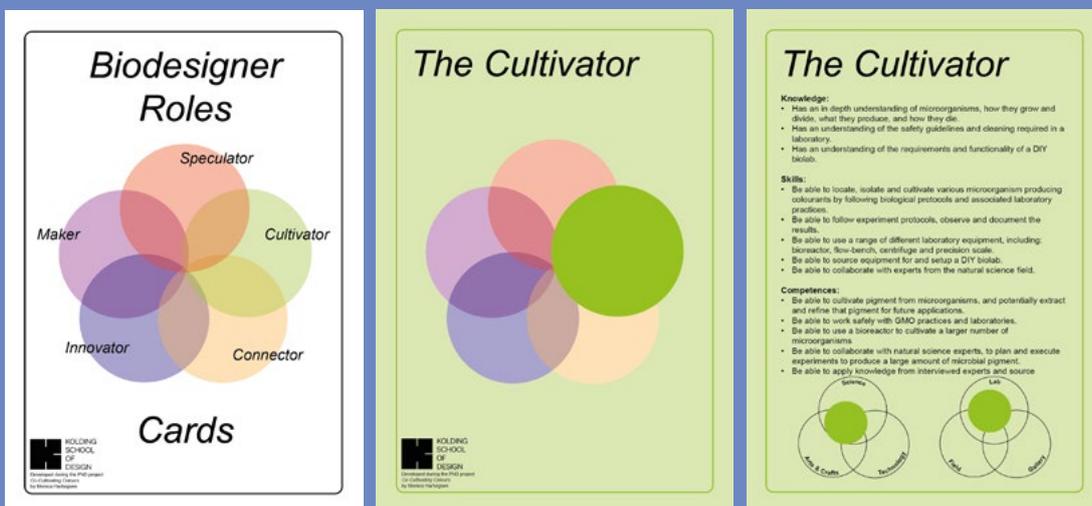
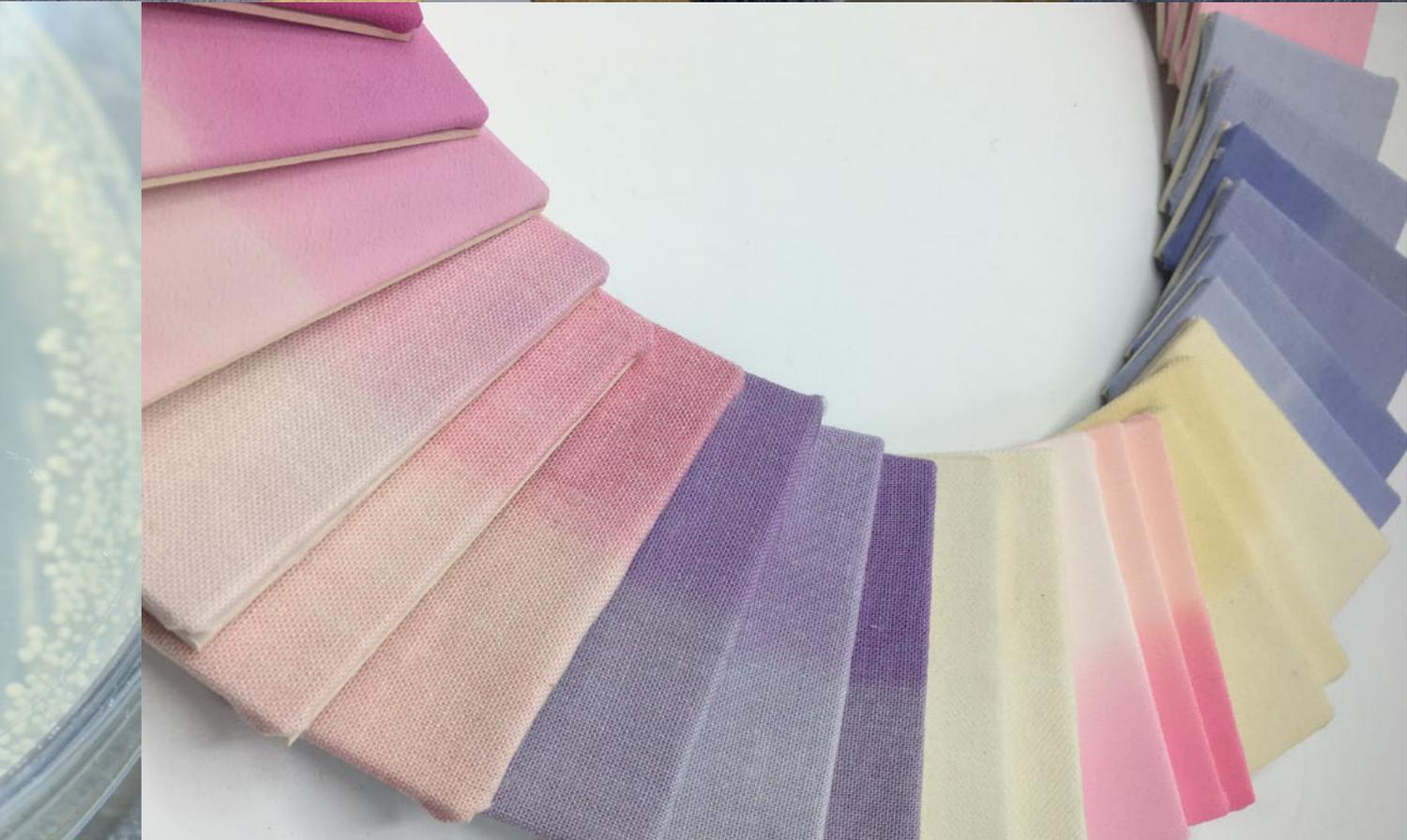


Figure 12 Examples from The Biodesigner Roles Cards (p. <?>).





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