Table of Contents

[Biomaterials Teaching Toolkit (working title) 2](#_Toc90042214)

[DIY Microbiology 7](#_Toc90042215)

[Biolab rules 7](#_Toc90042216)

[Handwash experiment: - what is living on your hands? 8](#_Toc90042217)

[Biosafety: containment levels 10](#_Toc90042218)

[Set up a community biolab 11](#_Toc90042219)

[Lab design 12](#_Toc90042220)

[Cone of protection 13](#_Toc90042221)

[Aseptic techniques 13](#_Toc90042222)

[DIY Applied mycology 15](#_Toc90042223)

[Morphology of tools 15](#_Toc90042224)

[Materiology 17](#_Toc90042225)

[Install a sample management tool 17](#_Toc90042226)

[Define your eco-compatibility principles 17](#_Toc90042227)

[Collaborative open-source archiving 18](#_Toc90042228)

[What is a material experience? 19](#_Toc90042229)

[Material-objects 20](#_Toc90042230)

[Tactility video 21](#_Toc90042231)

[What is a material property? 21](#_Toc90042232)

[Recycling 23](#_Toc90042233)

[Industrial processing and conversion techniques 23](#_Toc90042234)

[Extractive Manufacturing 23](#_Toc90042235)

[Industrial processing and conversion techniques 23](#_Toc90042236)

[Additive manufacturing 24](#_Toc90042237)

[Industrial processing and conversion techniques 24](#_Toc90042238)

[Casting and moulding 24](#_Toc90042239)

[Industrial processing and conversion techniques 24](#_Toc90042240)

[Transforming 25](#_Toc90042241)

[Industrial processing and conversion techniques 25](#_Toc90042242)

[Assembling 25](#_Toc90042243)

[Industrial processing and conversion techniques 25](#_Toc90042244)

[Finishing - Industrial processing and conversion techniques 26](#_Toc90042245)

[Mono-material connections 28](#_Toc90042246)

[Bio-based materials 29](#_Toc90042247)

[TO DO? Better Together (combining polymers) 29](#_Toc90042248)

[Morphology of ingredients in biofabrication 29](#_Toc90042249)

[Agar bioplastic 29](#_Toc90042250)

[Alginate bioplastic 31](#_Toc90042251)

[Carrageenan bioplastic 32](#_Toc90042252)

[Gelatin bioplastic 33](#_Toc90042253)

[TO DO: Chitosan bioplastic 33](#_Toc90042254)

[Mycelium-hemp composite 34](#_Toc90042255)

[Onion skin pigment extraction 35](#_Toc90042256)

[Starch bioplastic 36](#_Toc90042257)

[Milk composite 37](#_Toc90042258)

[Fruit leather 38](#_Toc90042259)

[Microbial leather 39](#_Toc90042260)

[Fish leather 40](#_Toc90042261)

[Flower paper 41](#_Toc90042262)

[Madder pigment extraction 42](#_Toc90042263)

[Oak gall tannin extraction 43](#_Toc90042264)

[Fungal dye 44](#_Toc90042265)

[DIY pH paper 45](#_Toc90042266)

[DIY iron acetate 46](#_Toc90042267)

[Scouring and mordanting wool fibres 47](#_Toc90042268)

[Scouring and mordanting silk fibres 48](#_Toc90042269)

[Dyeing cellulose fibres 49](#_Toc90042270)

[Critical Making 50](#_Toc90042271)

[(Un)making the mold 50](#_Toc90042272)

[Being a 3D printer 50](#_Toc90042273)

[Demystifying biotechnology 51](#_Toc90042274)

[Shit, Hair, D(isg)ust 52](#_Toc90042275)

[Biodata processing 53](#_Toc90042276)

[Developing a bio art or biodesign project 54](#_Toc90042277)

[Glossary of Bio-everything 55](#_Toc90042278)

[A history of design & nature 55](#_Toc90042279)

[Designed to disappear 56](#_Toc90042280)

[Waste walk 57](#_Toc90042281)

[Beyond biomimicry 58](#_Toc90042282)

[Cross-disciplinary reading 61](#_Toc90042283)

[TO DO? Bioremediation 61](#_Toc90042284)

[Title 62](#_Toc90042285)

# Biomaterials Teaching Toolkit (working title)

Accompanying booklet (A3 folded in six = 12 squares in total, 6 squares per side)

*The order has to do with the way of folding*

|  |  |
| --- | --- |
| Header:  Critical creative research on new material futures  LOGOs  Header:  Biomaterials Teaching Toolkit  Square 1 | BIOMATERIALS TEACHING TOOLKIT  *Materials can help to expose the cracks of our ailing systems; because they have the power to solidify new norms; because they can make more preferable futures tangible.*  *–* Liz Corbin, materials researcher & designer  What you have in your hands is a teaching toolkit for critical materials research in higher design and arts education. It comes out of a 2-year project at the Amsterdam University of Applied Sciences, where we – a group of design educators and/or researchers – developed ways to invite third year bachelor students to explore making practices that center ecosystems rather than human systems. With this toolkit, we share our tried and tested activities, which take bio-based design materials and their unique properties as a point of departure, and offer hands-on activities to critically engage in sustainable material research.  Materials are all around us, and therefor easy to ignore. But as Liz Corbin says: they also solidify norms. Making processes don’t have to be set in stone to become so normal that we can hardly imagine other ways of doing things. Our attitudes to materials shape the way we think, imagine and create things and identities. This toolkit will provide you ways to see materials anew, by learning more about them, exploring alternatives, or altogether defamiliarizing ourselves from what we think materials can and should do.  ***A critical, transdisciplinary approach to (material) making***  The activities described in these cards invite learners to draw together insights from material science, industrial manufacturing, microbiology, material culture, design and arts as well as ancient crafts practices. Creating “new” natural materials here refers less to inventing novelty materials or being a contemporary nano-alchemist or genetic engineer. It refers to a new way of looking at materials that share a common characteristic: they are created from feedstocks that were once alive and regenerative. And more radically: some are *biomanufactured* by leveraging living systems without killing those living systems at all, instead enveloping them into making processes without depleting or destroying them. This toolkit helps you explore natural materials and growth processes in a hands-on way, while asking questions that unsettle what everyday human-made objects look and feel like, and the creative strategies, manufacturing processes and social and ecological systems involved in creating them.  ***How to use this toolkit***  From cooking bioplastics in your kitchen, to hands-on collaborations with fungi: these activities will help you get acquainted and collaborate with natural substances and living organisms to inspire regenerative and sustainable design and arts projects. The prompts provided in this toolkit can be combined to create longer programs in higher education, based on interest, audience, resources and time available.  *Themes and categories*  The cards are structured around four themes that each contribute to understanding and making sustainable materials and sustainable modes of production. Depending on your aim and audience you can combine cards from the categories *Materiology*, *Bio-based Materials*, *DIY Microbiology* and *Critical Making*. Each category contains a mix of reflective, practical, creative and more conceptual activities. We recommend teachers explore each activity with peers first to get an understanding of the workflow, needs, and potential risks to be aware of.  The set is not exhaustive and certainly leaves room for many more and different activities. But it aspires to give educators (as well as students, even researchers) practical starting points to imagine material futures without petrol-based plastics and toxic materials. |
| Coverpage  Square 2 | Biomaterials Teaching Toolkit  *A teaching resource for critical materials research* |
| Square 3 /4/5/6 | ***Colofon***  Amsterdam University of Applied Sciences  Faculty of Digital Media & Creative Industries  Rhijnspoorplein 1, 1091GC Amsterdam  <https://www.amsterdamuas.com/>  Title: Biomaterials Teaching Toolkit  Authors: Loes Bogers & Sam Edens  Contributors: Micky van Zeijl, Ista Boszhard  Publisher: Amsterdam University of Applied Sciences  Partner: Textilelab Amsterdam, Waag  Typeface: Calibri  Paper: Biotop 80 g/m, Circle 250 g/m  Images: All images by authors and AUAS students unless stated otherwise.  Funded by NRO Comenius Teaching Fellowship for educational innovation, awarded to Loes Bogers in 2020.  Many thanks to all our students for their wonderful participation, crazy ideas and honest feedback.  This printed toolkit is a limited edition. The booklet and cards are printed with soy-based ink on a RISO printer, on recycled and FSC-certified paper. The purse is made from 100% Oekotex certified undyed wool felt, sewn together with 100% silk yarn, and a hand-spun string made from Dutch wool. The wool is cleaned and mordanted with alum and cream of tartar, and is ready to be dyed with most natural dyes, such as madder, weld, cochineal or other.  A digital version of the toolkit is available for download at: <https://github.com/loesjebo/biomaterials_toolkit>  ***Disclaimer***  This book is presented solely for educational purposes. The authors and publisher do not offer it as professional services advice. The best efforts were made in preparing this kit, but the authors and publisher make no representations or warranties of any kind and assume no liabilities of any kind with respect to the accuracy or completeness of the contents and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. Neither the author nor the publisher shall be held liable or responsible to any person or entity with respect to any loss or incidental or consequential damages caused, or alleged to have been caused, directly or indirectly, by the information contained herein.  ***Recommended suppliers (NL)***  Finding the things you need can be a chore, here’s our list of recommended suppliers in the Netherlands:  Eurofysica – lab supplies for schools  Labshop – lab supplies, chemical compounds, cellulose  De Hekserij – chemical compounds, e.g. calcium chloride  Unique Products – carrageenan and alginate (via Friedas.nl)  Brouwland – light malt extract, activated carbon (bulk)  De Molenwinkel – rye grain and wheat bran (bulk)  Meervilt – mordants and natural dyes  Belspo.be – microorganisms (institutional customers only)  Mycelia.be – mushroom strains, consultancy & training  Homegreen.nl – mushroom strains (also sporeless varieties)  Carolina.de – slime mold sclerotium & educational materials  Grown.bio – colonized substrates for DIY mycelium products  Rotterzwam – DIY oyster mushroom growkit to do at home\*  Yaya Kombucha – kombucha starter kits\*  Startercultures.eu – cultures for food fermentation\*  *\* Do not mix non-food and food applications and organisms. Keep utensils separate, don’t grow edibles in a biolab where other experiments also take place.* |
| Header title:  Bio-based Materials  square 7 | This category contains recipes and protocols to create various kinds of bio-based materials. Ranging from cooking bioplastics and growing fungal biocomposites to ancient techniques such as fish leather tanning and natural dyes. |
| Header title: Materiology  Square 8 | These activities explore the intersection between material science and material experience. How can we know materials? How can we share this knowledge and experiences? In addition, cards about industrial processing and conversion techniques help to explore the possibilities of a given material more extensively. |
| Header title:  DIY Microbiology  Square 9 | The cards with this tag explain basic techniques, protocols and etiquette for working in a microbiological lab setting safely. It also provides resources to get informed about lab safety, lab design and suitable organisms for use in schools and community labs. *Note: do not start any microbiological experiments without getting guidance and information.* |
| Header title:  Critical Making  Square 10 | This section provides activities – sometimes accompanied with readings – that help to rethink existing norms and values around matter, materials and human-made objects. The cards suggest exploring the history and changing use of core concepts across different fields, and provides practical *defamiliarization* exercises that help us see things anew. |
| Header title:  Select & Explore  Square 11 and 12 | [Image: front of the card and back of the card]    Introduction   * The short description allows you to quickly assess whether the activity or method on the cards suits your needs.   Category   * Depending on what learners already know and depending on what topic you want to center your activities, the toolkit is divided in four categories. Cards can be about materiology, bio-based materials, DIY-microbiology, or critical making.   Recommendations   * Depending on what learners already know and depending on what topic you want to center activities, the toolkit is divided in four categories. Cards can be about materials science, bio fabrication, diy-microbiology, or critical making.   Tasks  The steps that need to be taken in order to execute the activity |

## DIY Microbiology

|  |  |
| --- | --- |
| title | TO DO: Microbial dye |
| Short description |  |
| Tasks | Basis, zakken, resists |
| why/when/note/output/next |  |
| Reference |  |
| See also |  |
| Ideas for image |  |

|  |  |
| --- | --- |
| title | TO DO: Microorganisms to get to know Superpowers suitable for schools |
| Short description |  |
| Tasks | Reishi  Gray oyster  Janthino  Algen  Slime mould  Acetobacter |
| why/when/note/output/next |  |
| Reference |  |
| See also |  |
| Ideas for image |  |

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| **title** | Biolab rules The importance of Good Microbiological Laboratory Practice (GMLP) |
| Short description | GMLP rules are aimed at containing uncontrolled spread of microbes, to protect your experiments from becoming contaminated with external microbes, and to protect you and others from the small possibility of infection. |
| tasks | Study the manual provided in the reference. Design a poster together, listing all the rules, make it visible in your shared lab space:   * Report spills or damage immediately to a lab technician. * Only do work you are trained and instructed to do. When in doubt: ask! * No eating, drinking or hand-to-face contact: may cause accidental ingestion of hazardous materials or culture. * Label everything, always: so other people are aware of their contents (date, name, organism, growth medium) * Handwashing: before microbiological work to avoid contaminating your experiments with unknown organisms, and after to ensure no living cultures accidentally leave the lab on your hands. Wear a lab coat when in the lab. * Never leave open flames or running pressure cookers: they are potential fire hazards and need to be monitored, always. * Dispose of waste properly: all living cultures and materials that have been in contact with living cultures need to be steam autoclaved before disposal. Surfaces are to be disinfected with 70% denatured alcohol after use. * Keep personal items (notebooks, phones, laptops, coats) outside the lab and at all times away from the lab bench. * You are not allowed to take any living cultures from the or bring in living cultures without permission from a technician. |
| when/why/note/output/next | **Why**  Good Microbiological Laboratory Practice (GMLP) is one of the main ways to ensure safe practice when working with microorganisms.  **When**  This is a good introductory activity to familiarize students with key concepts, tools and rules in a biolab, before starting any investigations.  **See also**: handwash experiment |
| Reference | Basic Practical Microbiology: A Manual (2016) Microbiology Society: <https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html> |
| Ideas for image | GMLP.JPG |

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| --- | --- |
| Title | Handwash experiment: - what is living on your hands? |
| Short description | Practice pouring agar plates and discover |
| tasks | **Handwashing experiment**  Study the Basic Practical Microbiology Manual in preparation for class, followed by the handwashing experiment. Students practice pouring plates using aseptic technique, and learn to use the autoclave to sterilize media and materials.  Prepare a nutrient agar (500 ml water, 1.5 g yeast extract, 2.5 g peptone, 2.5 g non-iodized salt, 7.5 g agar agar)  Autoclave for 45 mins, allow to cool to 35C  Pour agar into sterilized petri dishes using aseptic technique  Take a bathroom and coffee/tea break until agar sets  Group 1 washes hands w soap and warm water for 20 sec  Group 2 washes hands with only water  Group 3 desinfects hands with hand sanitizer  Group 4 does not wash or desinfect their hands at all  Ask each student to press a finger onto the agar, close the dish, seal with parafilm and label it  Incubate for 2-7 days at room temperature  Study the results without opening the plates  Autoclave the plates for 20 mins afterwards |
| when/why/note/output/next | **Why**  Learn why lab rules exist, and what Good Microbiological Laboratory Practice entails, practice with a hands-on experiment.  **When**  This is a good introductory activity to familiarize students with key concepts, tools and rules in a biolab, before starting any investigations.  See also: Biolab rules |
| Reference | Basic Practical Microbiology: A Manual (2016) Microbiology Society: <https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html> |
| Ideas for image | handwashing.png |

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| **title** | Biosafety: containment levels |
| Short description | To make sure that microbiology experiments stay safe and that the work environment is healthy, by familiarizing yourself with biosafety levels. |
| tasks | Discussion prompt 1: Read the biosafety levels manual and discuss the importance of biosafety levels or *levels of containment*. What is the difference with the school levels discussed in the manual? Why do you think they address those specifically?  Discussion prompt 2: Find out under which biosafety level each of these organisms is typically classified (may differ per strain!). Research whether any of these is related to illnesses in humans. Discuss whether you would consider using these organisms in a school biology setting and which conditions you might be set for working with these.  *Pleurotus ostreatus | Serratia Marcescens | E.coli | Komagataeibacter Xylinus*  Discussion prompt 3: why is working in the lab with a Gray Oyster to make materials different from growing these in your kitchen, and different from eating store-bought grey oysters to use for dinner? Why can you eat the mushrooms that you grow in your kitchen (see also Rotterzwam growkits), but you cannot eat mushrooms you grow in a lab where you are also experimenting with other organisms? |
| When why note | **Why**  Starting to understand how required levels of cleanliness and containment depend on a number of interrelated factors (skill level, protocol and use, volume of culture) enables you to critically assess risks and possibilities.  **When**  After you have done some textbook experiments, and are starting to wonder and ideate what else might be possible.  **Next**  Grow Gray Oyster Mushrooms in your kitchen and eat them! <https://www.rotterzwam.nl/collections/all/products/paddenstoelen-growkit-oesterzwammen> |
| Reference | Microbiology Society (2016) Basic Practical Microbiology: a Manual: <https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html> |
| See also | Starting a community biolab |
| Ideas for image | biohazard.png by Kelsey Chisamore, the Noun Project |

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| **title** | Set up a community biolab |
| Short description | Safe practice in microbiology requires a designated, limited access space and training. A proper environment prevents contamination and health hazards. This cards contains pointers to get informed before doing practical work. |
| Tasks | Study the *Community Biology Biosafety Handbook* thoroughly with your team (see reference)  Consult someone with experience as lab technician overseeing practical microbiology work in high schools.  Find a biosafety advisor who can help with risk assessments (in NL: RI&E).  Find suppliers of high school lab materials (e.g. Eurofysica, Carolina).  Learn aseptic technique and Good Microbiological Laboratory Practice (GMLP) by getting training from an expert.  Write step-by-step protocols defining the acceptable experiments in your lab, review protocols and changes in the future with an expert. |
| When why note | **Why**  Establishing a shared foundation for biosafety and security practices is key when you are considering to set up a community lab in your institution or community. Familiarizing yourself with resources to do so enables you to conduct safe lab practices with non-biologists.  **When**  When you want to create an open-access laboratory facility that supports non-biologists such as artists and designers to explore microbiology in a hands-on way. |
| Reference | Angela Armendariz, Patrik D’haeseleer and others (ongoing) *Community Biology Biosafety Handbook*: <https://bit.ly/3k9Tkz9> |
| See also | Biosafety Containment Levels | Lab Design | Organisms to Get to Know | Biolab Rules |
| Ideas for image | setupbiololab.jpg |

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| **title** | Lab design |
| Short description | Whether setting up a space for the first time, or moving to a new space, consider the following list of recommendations for materials to use, and the infrastructure required to handle them when designing a biolab. |
| Considerations | * Walls and floors should be smooth, impermeable to liquids and easy to clean. No carpets or flammable materials. * Benchtops should be impermeable to liquids including disinfects, and chemicals. Benchtops should be scratch resistant and have no open seams. * Sink for handwashing, dishwashing and disposal of non-toxic and non-hazardous liquids should be provided. * Lab furniture such as chairs and stools should be non-porous and easily cleaned (e.g. vinyl, hard plastic, rubber) * PPE storage such as lab coats should be available upon entry. Lab coats need to be separated, not stacked. * Personal storage space non-lab items need to be stored outside the lab (e.g. coat racks, closets, lockers). * Office space is separate from labspace. Demarcate space for eating, drinking and office work * Fire safety equipment and smoke detectors are often legally required. Fire extinguishers should use carbon dioxide or dry chemical type A-B-C extinguishers. * Ventilation ideally provides inward airflow without circulation. If mechanical ventilation is not possible, install screens to prevent insects from entering through windows. |
| Reference | Angela Armendariz, Patrik D’haeseleer and others (ongoing) “Lab Infrastructure & Design” in: *Community Biology Biosafety Handbook*: <https://bit.ly/3k9Tkz9> |
| See also | For the Netherlands, see also article 9.1.1.1.1 and 9.1.1.1.2 of the laws regarding work with genetically modified organisms as a guideline for space design: <https://wetten.overheid.nl/BWBR0035072/2021-10-01#Bijlage9> |
| Ideas for image | labdesign.JPG |

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| --- | --- |
| **title** | Cone of protection |
| Short description | Transferring organisms or inoculating plates or substrates with organisms needs to be done in a clean environment to prevent contamination. Working with a sterile bubble is a sterile technique for working on an open bench. |
| tasks | The updraft from the heat generated by the Bunsen burner prevents particles in the air from falling into your petri-dish. The cold air that is sucked in from beneath comes from the alcohol-covered bench, thus creating a sterile bubble with a diameter of about 20 cm. Keep the organisms and dishes within the bubble and keep your movements (with a scalpel or inoculation needle) within the bubble.   * Close windows and doors and let everyone know you will be inoculating and lighting the flame​ * No talking, no walking around​ * Work on a smooth, even and cleaned surface * Clean everything with 70% alcohol (let it dry on its own)​ * Light the Bunsen burner. The blue flame is the hottest (tweak the oxygen supply to change the flame from yellow to blue) * Work within 20 cm radius of flame​ * Don't wear gloves or synthetic face masks (can glue to skin when hot)​ * Point tip of alcohol bottle away from flame at all times!​ * Open petri dishes as little as possible, open petri dishes towards the flame​ (open top like a clamshell towards the flame) * Pass neck of bottle through the flame before and after each pour to sterilize the neck​ * Work fast but don't rush, get comfortable​ * Don't touch the gas burner while it's on​ |
| See also | Practice inoculating |
| Tools | Bunsen burner, lighter, alcohol 70% |
| Reference  + See also: | “The Sterile Workspace (n.d.) Neosynbio: <https://www.neosynbio.com/the-sterile-workspace>  Basic Practical Microbiology: A Manual (2016) Microbiology Society: <https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html> |
| Ideas for image | Nieuwe foto maken |

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| --- | --- |
| **title** | Aseptic techniques Pouring plates, inoculating with loops, pipettes and scalpels |
| Short description | Aseptic technique is a set of procedures to prevent unwanted microorganisms from contaminating your experiments and your environment. |
| Tasks | Read pages 6-15 from the manual listed below and practice the following techniques. Practice the procedures “dry” (without contents) a few times to get used to the motions.  **Sterilizing tools & Media**   * Steam autoclave all growth media, tools and materials for 20 minutes (45 mins if more than 500 ml liquids). Tools can be wrapped in aluminum foil, so they can be kept closed and sterile until use.   **Pouring plates (aseptic technique)**   * Prepare growth media and autoclave media and petri dishes to sterilize * Allow to cool until 35 degrees C. The agar sets below this temperature. Agar that is too hot will give condensation inside the petri dish. * Pour the plates using aseptic technique (p. 13 of manual listed below) * Wrap poured plates in cling film and store in fridge if not used immediately. Do not use refrigerated agar that is cracked or broken.   **Different inoculation techniques**   * *Inoculation loop:* pass it through the flame before and after every action, ensuring it is red hot. Flame the loop last (start at the base) to prevent aerosol formation of culture. * *Scalpel*: autoclave before use, then douse with 70% alcohol. Pass it through the flame briefly before each action (not red hot). Used to transfer and inoculate e.g. mycelium. * *Micropipette*: glass pipettes can be autoclaved and flamed. Plastic disposable tips of micropipettes can be autoclaved for 20 mins inside the box. Keep the box closed as much as possible to keep tips sterile. |
| See also | Cone of protection |
| Tools | Bunsen burner, alcohol, scalpel/loop/pipette, agar plates, glass bottle. |
| Reference | Basic Practical Microbiology: A Manual (2016) Microbiology Society: pp. 6-15. <https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html> |
| Ideas for image | practice\_inoculation\_loop.jpg |

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| **title** | DIY Applied mycology Collaborating with fungi |
| Short description | Mycology is the study of fungi and their applications in several industries (food, materials, pigments, medicine, bioremediation). The availability of tools and DIY processes make this field accessible to enthusiasts. |
| tasks | **Set up a community biolab (see related cards)**  Find suppliers of lab materials (e.g. Eurofysica)  Learn aseptic technique and Good Microbiological Laboratory Practice (GMLP)  **Choose a well-documented strain**  Pleurotus Ostreatus (Gray Oyster) and Ganoderma Lucidum (Reishi) are foodsafe strains, suitable for beginners. Find a supplier who can sell you *sporeless* strains to avoid unwanted sporulation (e.g. Homegreen in NL)  **Learn how to grow mycelium in a petri dish (see references)**  Learn how to make a *malt-yeast-agar* and *potato dextrose agar*  **Learn how to create a grain jar/grain spawn (see references)**  Learn how to *prepare*, *sterilize* and *inoculate* a grain jar  **Learn how to colonize a bulk substrate to create fungal composites**  Find out which substrates your strain thrives on (what it likes to eat)  Learn how to *pasteurize, inoculate* and *incubate* bulk substrates Learn maintain and dry a bulk substrate  **Learn how to train a strain to digest a particular food**  Train your mushroom to eat abundant waste, or train it for mycoremediation |
| \*ingredients  \*tools \*reference \*see also | **References**   * Peter McCoy (2016) *Radical Mycology* * Freshcap Mushrooms Blog and video channel <https://learn.freshcap.com/growing/> and <https://www.youtube.com/c/freshcapmushrooms>   **See also**  Set up a community biolab  Aseptic techniques  Mycelium-hemp composite |
| Ideas for image | Mycelium\_agar.JPG |

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| **title** | Morphology of tools Finding alternatives to specialist equiment |
| Short description | Many people in the DIY biology realm have considered ways to make microbiological work more accessible by finding alternatives to expensive specialist equipment. Some tools and materials can be substituted. |
| tasks | **Glassware**  You might find that lab grade glassware such as glass bottles can get expensive. Sterilizing media can also be done in glass jam and yogurt jars with a lid. Glass is used because it can withstand the heat of an autoclave (121 degrees C), polypropylene (plastic marked with the sign PP5) which is often used in the production of food containers, is also autoclavable.  **Gas exchange**  Many microorganisms are aerobic, which means they require fresh air to grow. Others release gases, which can build up in a plate or jar. *Parafilm* is commonly used to ensure gas exchange while providing a barrier for contaminants. Syringe filters, synthetic filter disks (Tyvek) or synthetic wool (e.g. Fibrefill, or non-absorbent synthetic wool) can be used to plug a little air vent drilled into the lid of your jar or bottle.  **Steam autoclave**  Pressure cooker pans are used in many schools as an alternative. Use of *autoclave tape* is recommended. For steam sterilization to occur, the entire item must completely reach and maintain 121°C for 15–20 minutes with steam exposure at 15 PSI (or 45 mins for textiles, and 500 ml liquids or more).  **Incubator**  Make your own using instructions from the Biohack Academy program, or look for incubators used to hatch reptile eggs.  **Autoclaveable waste bags**  Invest in different sizes as they can also function as a container for incubated cultures, when closed with rubber band and plugged with a material that serves as gas exchange material (see above). Incubate upright to avoid contamination. |
| See also | * [https://learn.freshcap.com/growing/using-pressure-cookers-for-growing-mushrooms/#](https://learn.freshcap.com/growing/using-pressure-cookers-for-growing-mushrooms/) * <https://archersmushrooms.co.uk/how-to-make-grain-spawn-jars/> * <https://github.com/BioHackAcademy/BHA_Incubator> |
| Ideas for image | morphology\_tools.JPG |

## Materiology

|  |  |
| --- | --- |
| title | Install a sample management tool |
| Short description | When you want to maintain a material archive for longer, it can help to invest energy in setting up sample management software that helps you organise your samples and generate printable labels. |
| Tasks | Contact your systems administrator (or find one)  Ask them if they are able to install the software below on your server  Decide who you want to make admins  Update the logo to your organisation’s logo  Add users and explore together how the tool works  Negotiate things that are unclear or unusful to you  Read the about page for more info: <https://samplemanagementtool.org/#/about>  Start archiving your material samples! |
| why/when/note/output/next | **Why**  The Sample Management Tool is a label generator and database to support creative communities in documenting and sharing material experiments. It was designed around the idea of collaboratively building an archive of alternative design materials with an emphasis on materials that are easily renewable, reusable, (home) compostable within 90 days, locally abundant and make use of local waste streams.  **When**  After you have done some experimenting and want to commit to material experimentation for a bit longer. Is designed for use in university and art school courses to help teachers and students showcase material experiments in shared studios, to learn from and get inspiration. |
| Reference | Software: <https://github.com/Koziad/visualm-5>  Example of tool in use: <https://samplemanagementtool.org> |
| See also | This tool was developed based on the OS Material Archive, a project developed at Textile Lab Amsterdam by Cecilia Raspanti: <https://tcbl.eu/project/os-material-archive> |
| Ideas for image | install\_sample\_tool.png |

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| title | Define your eco-compatibility principles |
| Short description | Sustainability is not something absolute that can be measured: it depends on the context a material is applied in, and the life cycle of the object. Shared guidelines help to systematically classify and compare different options. |
| Tasks | **1. Research & define**  Research these terms and define them in 1 or 2 sentences. Try to come to an agreement with your peers on what definition you agree on, so you have a yardstick to assess when these terms apply to a particular material.  **2.** **Suggest ways to research the parameters**  Describe methods to look into each of these for a given material or feedstock.  **Low environmental impact in use:**   * Eco-efficiency (relates to embodied energy & emissions) * Short distribution chain (relates to sourcing of feedstock) * Non-toxicity (relates to toxicity of material when in use) * Renewable resources (relates to time required for resource to replenish itself, e.g. regrow in nature)   **Extension of the useful life of materials:**   * Durability (is the lifespan of material in proportion to lifetime of use of the product it is used for?) * Recyclability (homogeneity of material, and quality of recycled output) * Biodegradability (time and conditions required)   **Ethical production:**   * Is the feedstock or semi-finished product or ingredient manufactured in a responsible way? |
| why/when/note/output/next | **Why**  If a product is to be truly eco-compatible during its life cycle it must minimise, if not eliminate, resource consumption (energy and materials) and emissions (air, water, and solid waste). Lerma, diGiorgi & Allione developed a multi-criteria interpretation system top help designers interpret the environmental performance of design materials in a context-aware way.  **Output**  Shared definitions that work as a yardstick to help you assess when you can make certain claims about a material (e.g. say it is biodegradable).  **Next**  Select and - if necessary - simplify some of the parameters to use them as guidelines in your projects. |
| Reference | Beatrice Lerma, Claudia diGiorgi & Cristina Allione (2013) Design & Materials: Sensory perception sustainability project: p. 103: <https://bit.ly/3BHM9nZ> |
| See also | Here’s an adaptation used for a material archive: <https://samplemanagementtool.org/#/about> |
| Ideas for image | eco-compatibility.png |

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| title | Collaborative open-source archiving |
| Short description | Documenting, archiving and presenting your material explorations together opens up access to a wealth of options you could never explore alone. |
| Tasks | **Discuss the idea of *open-source***  What does it mean? Where does it come from? Could it be applied to making materials? What could be pitfalls? What are the benefits? Do you have any hesitations?  **Decide what system you will use**  Design, or choose a template all materials will be archived with  Make sure there’s a template for small, medium and large samples  Find a place where you can display everyone’s samples safely  Decide on the paper stock (something that fits an office printer)  **Do material experiments**  Keep notes on all material experiments you do: write down details on ingredients, cooking and drying time, references, etc.  **Document and archive**  Collect all your notes and fill out the labels for your samples.  Make sure to list a main reference and state which changes you made to create a new variation (your “contribution to the field”).  **Display**  Trim your materials if needed, and mount them onto the labels  Attach a hang tab or other system to hang them up  Put them in your material archive. |
| why/when/note/output/next | **Why**  Having a large collection of small variations gives you a good feeling for how material recipes can be tweaked to achieve very different results. By having a sample available with a recipe attached, you get a better idea than from a picture or piece of text alone.  **When**  When you find yourself in a group of people who are interested in experimenting with natural design materials, and believe you could learn more from each other than alone.  **Next**  If you want to formalize the process, consider installing software to build your own online/offline archive and sample management tool: <https://samplemanagementtool.org/> |
| Reference | OS Material Archive developed at Textile Lab Amsterdam (2016-ongoing): <https://tcbl.eu/project/os-material-archive> |
| See also | Labels designed by Maria Viftrup for Textile Lab Amsterdam can be downloaded here: <https://bit.ly/3wdJkdb> |
| Ideas for image | collabarchiving.jpg |

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| **title** | What is a material experience? materials as being simultaneously technical and experiential |
| Short description | The notion of *materials experience* emphasizes the role of materials as being simultaneously technical and experiential. People experience materials in products at four experiential levels, namely sensorial, interpretive, affective and performative. |
| tasks | **Understand the material: technical**  tinker with the material (e.g. make variations on the recipe)| test material’s properties, compare to similar materials | describe opportunities and constraints | explore and describe possible manufacturing processes  **Understand the material: experiential**  Explore how the material is experienced by people using the MA2E4 toolkit. Inquire about their experiences on the *performative*, *sensorial, affective* and *interpretive* level.  **Create a materials experience vision & patterns**  Express how you envision the material’s role in creating functional applications and unique user experiences, in relation to other products, people and wider contexts. See also reference below.  **Designing material/product concepts**  Integrate all findings into 3 product concepts that mobilize the material’s unique properties in a meaningful way. |
| when/why/note/output/next | **Why**  Developing an *experiential characterization* of a material entails investigating of how a material is received, what it makes people think, feel and do. It helps designers mobilize unique material qualities in design processes.  **When**  When you’ve developed one or more interesting materials and want to systematically explore their possible application in real products/objects. |
| Reference | Elvin Karana, Bahareh Barati, Valentina Rognoli & Anouk Zeeuw van der Laan (2015) Material Driven Design (MDD): A Method to Design for Material Experiences. International Journal of Design. |
| See also | Serena Camere & Elvin Karana (2018) MA2E4 Toolkit: Experiential Characterization of Materials: <https://materialsexperiencelab.com/ma2e4-toolkit-experiential-characterization-of-materials> |
| Ideas for image | materials\_experience.jpg  OF  materials\_experience2.png |

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| **title** | Material-objects Exploring form, function and materiality |
| Short description | Making, displaying and using series of *material-objects* can reveal specific aspects of material science in an experiential way. They communicate aspects of the relationship between form, functionality and materiality. |
| tasks | **Select**  Choose a form or object you are interested in exploring (e.g. a spoon, a sheet material)  Choose one or more material recipes you are interested in exploring further  **Make**  Create a series of objects that have the same form, but are made with a different material recipe.  Variations between the recipes can be very small and incremental (e.g. from no glycerine to a lot of glycerine), or substantial (e.g. using to entirely different recipes with different biopolymers).  Document each recipe in detail: weigh the ingredients, record cooking and drying times, measure temperatures etcetera.  **Share**  Allow others to explore the material series and documentation and explore what they’re able to understand about the materials by interacting with the series and comparing the samples.  Contribute the set to your material archive. |
| when/why/note/output/next | **Why**  The strategy of creating *material-objects* has been proposed by Zoe Laughlin (2010) as a way to express the relationship between form, function and materiality by letting the material itself represents the science behind materials in the context of a material library [24]. Laughlin demonstrated this by creating a series of cubes, spoons, bells, and tuning forks identical in form but made of different materials, whose properties can then be experienced and compared.  **When**  Designing a set of material-objects is a method to systematically understand and expand upon a material recipe by making variations on a theme.  **Output**  A set of material samples that are identical in form (the thing), but different in terms of the material (the stuff). Can be contributed to a shared material archive when documented together with recipes. |
| Reference | Zoe Laughlin (2010) How can the Science of Materials be Represented by the Materials Themselves in a Materials Library? <https://doi.org/10.13140/RG.2.2.16034.94405> |
| See also | <http://zoelaughlin.com/research-papers> |
| Ideas for image | material-objects.png |

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| **title** | Tactility video explore and document the sensory qualities of a material through video |
| Short description | Making a tactility video is a way to explore and document the sensory qualities of a material, by capturing the "feel" and sound of it in a video. |
| tasks | Select one or more materials to explore  Watch the tutorial video <https://bit.ly/3bIQHQh>  Lasercut a phonestand with the design file provided  Find a quiet place with even natural lighting  Set up your phone in landscape format  Shoot your tactility video(s)  Optional: include a link to the video in your archiving template |
| when/why/note/output/next | **Why**  This method provides a way to convey material properties in an accessible, non-textual way.  **When**  1) To spend time with your material experiments, and get to know their unique features 2) when you cannot provide access to the physical sample you can use this format to convey the feel and sound of a material.  **Next**  Asking others to manipulate the materials while you film them is also a way to research materials experience described in the card *What is a materials experience?* |
| Reference | Loes Bogers (2020) Tutorial for a tactility video: <https://class.textile-academy.org/2020/loes.bogers/projects/outcomes/tools_and_templates/tactilityvideo/> |
| Ideas for image | tactilityvideo.jpg |

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| **title** | What is a material property? Develop a shared vocabulary underpinned by example materials and tactile experiences. |
| Short description | Material sciences have developed shared vocabularies to describe material properties but are often underpinned by technical material tests and mathematical formulas. Develop a shared vocabulary underpinned by example materials and tactile experiences. |
| tasks | When we document material experiments, it is useful to have words to describe their properties and be specific about the differences between those words (e.g. hardness vs. elasticity vs. stiffness). Calculating a modulus however is demystifying for those without a background in material science. Finding a shared vocabulary based on tactile experience and discussion offers a contextual and embodied approach to defining and comparing materials and their properties within a community of practice.  Make duos and assign all property keywords  Formulate a one-sentence definition per property in your own words  Find an object that represents a material that would score very low on the scale, and one that represents a high score or even maximum of the scale for that property and one in the middle  Determine words that can express the minimum and maximum of the scale for each property (e.g. for strength: weak to strong)  List interactions with the material that help determine its score on the scale of that property  **Property keywords**  *Strength, hardness, transparency, glossiness, weight, structure, texture, temperature, shape memory, odor, stickiness, weather resistance, acoustic properties, scratch resistance, surface friction, weight, elasticity, ductility, wear resistance, water resistance, heat conductivity, creep, density*  **Class discussion**  Bring your objects to class and reflect on each other’s definitions  Assess how well the presented samples represent the range (min/max) of the scale for that property  Suggest better examples of the min/max/middle  **Visualize your shared vocabulary**  Together, make a visual overview of your shared vocabulary of material properties, words used to describe the range, and images of the sample materials that represent different points on the scale for each property. |
| when/why/note/output/next |  |
| Reference | Properties of Materials Introduction (2018) Science Learning Hub <https://www.sciencelearn.org.nz/resources/2659-properties-of-materials-introduction> |
| See also | List of materials properties, Wikipedia: <https://en.wikipedia.org/wiki/List_of_materials_properties>  Open-Source Universal Test Machine (2019) CNC Kitchen Youtube: <https://youtu.be/uvn-J8CbtzM> |
| Ideas for image | material\_property.jpg |

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| **title** | RecyclingIndustrial processing and conversion techniques |
| Short description | Fabrication is about processing raw materials and making parts that are suitable for assembly or manufacturing of goods for consumers. Knowing the major techniques for processing or conversion of materials helps you explore possibilities of biomaterials in depth. |
| “Tasks" | Explore your material recipes by subjecting them to different processing techniques.  Curate a series of samples showing possible processing techniques for one of your material recipes.  *Recycling* is re-using materials. Materials can be re-used for fabrication but often need to be decomposed before they are ready for fabrication. Depending on the nature of the material you can choose between several manners to decompose a material.  *Chemical recycling* (treatment to separate constituents for reuse)  *Mechanical recycling* (shredding, beating, grinding, crushing)  *Organic recycling* (composting to produce fuel or fertilizers) |
| Reference | Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry’s Guide to Materials and Technologies. |
| When/why/note/  output/  next | **Why**  Making bio-based materials is a form of fabricating. To imagine possible applications, we need to understand how they can be made into semi-manufactured materials and functional parts. |
| Ideas for image | recycling.jpg >> credit: John Lambert Pearson |

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| **title** | Extractive ManufacturingIndustrial processing and conversion techniques |
| Short description | Fabrication is about processing raw materials and making parts that are suitable for assembly or manufacturing of goods for consumers. Knowing the major techniques for processing or conversion of materials helps you explore possibilities of biomaterials in depth. |
| “Tasks" | Explore your material recipes by subjecting them to different processing techniques  Curate a series of samples showing possible processing techniques for one of your material recipes.  **Extractive Manufacturing** is starting with a block, plate or sheet of material and getting what you want by extracting material from it. You can either remove material (machining and engraving) or cut material (cutting).  *Cutting* (e.g. saws, scissors, knives, lasercutting, hotwire, piercing)  *Machining*(drilling, milling, turning, abrasion)  *Engraving* (laser engraving, etching, carving) |
| Reference | Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry’s Guide to Materials and Technologies. |
| When/why/note/  output/  next | **Why**  Making bio-based materials is a form of fabricating. To imagine possible applications, we need to understand how they can be made into semi-manufactured materials and functional parts. |
| Ideas for image | NOG DOEN |

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| **title** | Additive manufacturingIndustrial processing and conversion techniques |
| Short description | Fabrication is about processing raw materials and making parts that are suitable for assembly or manufacturing of goods for consumers. Knowing the major techniques for processing or conversion of materials helps you explore possibilities of biomaterials in depth. |
| “Tasks" | Explore your material recipes by subjecting them to different processing techniques  Curate a series of samples showing possible processing techniques for one of your material recipes.  With **additive manufacturing,** you build your design by adding or fusing materials in layers on top of one another.  *3D printing* (manual or digital/automated)  *Contact moulding* (alternating plastics with various substrates e.g. fibres, using a lay-up method. Also called composites) |
| Reference | Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry’s Guide to Materials and Technologies. |
| When/why/note/  output/  next | **Why**  Making bio-based materials is a form of fabricating. To imagine possible applications, we need to understand how they can be made into semi-manufactured materials and functional parts. |
| Ideas for image | additive\_manufacturing.JPG |

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| **title** | Moulding & Casting Industrial processing and conversion techniques |
| Short description | Fabrication is about processing raw materials and making parts that are suitable for assembly or manufacturing of goods for consumers. Knowing the major techniques for processing or conversion of materials helps you explore possibilities of biomaterials in depth. |
| “Tasks" | *Moulding & casting* are both processes in which materials in a non-defined shape or stage are directly converted into a defined shape. Casting is mostly done with metals and clay, and moulding with plastics.  Explore your material recipes by subjecting them to different processing techniques  Curate a series of samples showing possible processing techniques for one of your material recipes.  **Moulding & casting**  *Cast-moulding* (using liquids, open/closed mould)  *Rotational moulding* (multi-layered, open-closed)  *Extruding* (extruding and co-extruding, blow-moulding)  *Injecting* (injecting into mould, compression moulding)  *Sintering* (heating powders with or without binder, laser sintering) |
| Reference | Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry’s Guide to Materials and Technologies. |
| When/why/note/  output/  next | **Why**  Making bio-based materials is a form of fabricating. To imagine possible applications, we need to understand how they can be made into semi-manufactured materials and functional parts. |
| Ideas for image | processing\_conversion.jpg |

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| **title** | TransformingIndustrial processing and conversion techniques |
| Short description | Fabrication is about processing raw materials and making parts that are suitable for assembly or manufacturing of goods for consumers. Knowing the major techniques for processing or conversion of materials helps you explore possibilities of biomaterials in depth. |
| “Tasks" | Explore your material recipes by subjecting them to different processing techniques.  Curate a series of samples showing possible processing techniques for one of your material recipes.  *Transforming* encompasses techniques that change the state of a solid body of material in a controlled way. Although these techniques focus on the plasticity of a material, the coherence of the material and the mass of the material body remain intact. These techniques can be applied to cold material, semi-hot or hot material.  **Transforming**  *Folding* (cold vs hot, optional: scoring, applying stiffeners)  *Thermoforming* (vacuum forming, dome blowing)  *Stamping* (cold pressing sheets using molds) |
| Reference | Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry’s Guide to Materials and Technologies. |
| When/why/note/  output/  next | **Why**  Making bio-based materials is a form of fabricating. To imagine possible applications, we need to understand how they can be made into semi-manufactured materials and functional parts. |
| Ideas for image | processing\_conversion.jpg |

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| **title** | AssemblingIndustrial processing and conversion techniques |
| Short description | Fabrication is about processing raw materials and making parts that are suitable for assembly or manufacturing of goods for consumers. Knowing the major techniques for processing or conversion of materials helps you explore possibilities of biomaterials in depth. |
| “Tasks" | Explore your material recipes by subjecting them to different processing techniques  Curate a series of samples showing possible processing techniques for one of your material recipes.  Many products exist out of several parts, and even the smaller parts can be assemblages of different components. *Assembling* is connecting these parts in such a way that they can perform their intended function and can withstand the occurring load (in the form of pressure or friction, or else).  **Assembling**  *Joinery* (wood joinery, snap fit, interlocking, screws, nails)  *Sewing* (stitches: running-, basting-, slip-, back-, zigzag-, overlock-)  *Bonding* (using adhesives, heat or solvents)  *Folding* (riveting, rolled edges)  *Heat sealing* (heat welding, soldering, laser welding, friction welding) |
| Reference | Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry’s Guide to Materials and Technologies. |
| When/why/note/  output/  next | **Why**  Making bio-based materials is a form of fabricating To imagine possible applications, we need to understand how they can be made into semi-manufactured materials and functional parts. |
| Ideas for image | Assembling.jpg |

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| **title** | Finishing - Industrial processing and conversion techniques |
| Short description | Fabrication is about processing raw materials and making parts that are suitable for assembly or manufacturing of goods for consumers. Knowing the major techniques for processing or conversion of materials helps you explore possibilities of biomaterials in depth. |
| “Tasks" | *Finishing* is a surface treatment, either for protection or decorative purposes. Biomaterials can also be developed as a finish for other materials.  Explore your material recipes by subjecting them to different processing techniques  Curate a series of samples showing possible processing techniques for one of your material recipes.  Research the methods listed below:  **Finishing**  *Painting* (mix of binder, pigment, additives and solvents)  *Coating* (finishing processes for textiles and paper)  *Varnishing* (transparent paints, with or without color)  *Sanding & polishing* (sanding, chemical polishing, rubbing)  *Printing* (gravure, silkscreen, offset, UV-printing, stenciling, RISO) |
| Reference | Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry’s Guide to Materials and Technologies. |
| When/why/note/  output/  next | **Why**  Making bio-based materials is a form of fabricating. To imagine possible applications, we need to understand how they can be made into semi-manufactured materials and functional parts. |
| Ideas for image | finishing.jpg |

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| **title** | Mono-material connections |
| Short description | Designing interlocking connections – or how you can construct by connecting a material to itself - is a useful design strategy to create objects made from *mono-materials*. |
| tasks | **Select a material**  Select the material you want to design a connection for. Not all connections are transferable to other materials, so choose first, design after.  **Paper prototyping**  Prototype your material connections by drawing and making paper prototypes using scissors.  **Testing**  Test your paper prototypes with more accuracy. Design them in a vector drawing software and cut them with a laser cutter.  **Play & iterate**  Play with your modules, experiment with the kinds of shapes and structures you can make with them. Iterate on their design as new ideas come up. |
| when/why/note/output/next | **Why**  Many waste materials (e.g. leather offcuts) often come in small pieces, and making your own materials will initially happen on smaller scale before scaling up in size. Moreover, materials are easier to recycle when they are made of one single materials or *mono-materials.*  **When**  When you want to design products that don’t need to be deconstructed to be recycled. When you decide to work with a material feedstock that typically comes in small pieces.  **Next**  Translate your interlocking connection mechanism into a generative design. Using parametric design tools, you can make your modules *adaptive*, expanding their potential for creating complex 3D shapes, rather than only flat materials. |
| References | Zoe Romano (2019) *Circular Open-Source Fashion*, for Fabricademy. <https://class.textile-academy.org/classes/2019-20/week03/>and <https://oscircularfashion.com/> |
| See also | Tutorial interlocking tesselation design with Rhino & Grasshopper by Lorenzo Massini (2020) <https://youtu.be/Nb_lfpgM9WU> |
| Ideas for image | monomaterial.png >> credit Lorenzo Massini, 2020 |

## Bio-based materials

### TO DO? Better Together (combining polymers)

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| title | Morphology of ingredients in biofabrication |
| Short description | Studying the structure of biomaterials, and understanding the functions of ingredients in recipes will help you find new alternatives to experiment with. What are possible alternatives for each ingredient? |
| tasks | **Make a hypothesis**  Select a biomaterial recipe  Research what kind of compound each ingredient is  Use the functions graph as reference  Make a hypothesis of the function(s) of each ingredient  **Morphology**  Determine what could be alternatives for each ingredient  Locate alternatives that can be found in waste streams  Locate alternatives that are more locally abundant  **Experiments**  Recreate the biomaterial recipe by replacing one ingredient  Analyse the results, reassess your hypotheses  Do this with at least 3 times, changing one variable at a time |
| when/why/note/output/next | **Why**  Many biomaterials recgipes include purified store-bought virgin materials and foodstuffs. In order not to compete with food, it’s worth finding alternatives that can be sourced from waste streams, or alternatives that are more abundant in your environment. In many cases very pure food-grade ingredients can be avoided.  **When**  You’ve experimented with bioplastics and want to dig a little deeper so you can start developing new materials that are embedded and tuned to a specific local context.  **Next**  Locate an abundant waste stream that might be utilized. Contact a material scientist to further explore the chemistry of your materials. Share your experiments openly. |
| Reference | Functions graph (2021) Loes Bogers, Cecilia Raspanti & Sam Edens |
| See also | Kater Franklin and Caroline Till (2018) Radical Matter: Rethinking Materials for a Sustainable Future. |
| Ideas for image | morphology-ingredients.jpg |

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| Title | Agar bioplastic |
| Subtitle | Gum polysaccharide found in red algae |
| Short description | Agar, carrageenan, and alginate are *gum polysaccharides*. As food-safe biopolymers they are used widely in the food industry as thickeners and stabilizers but they also have good film-forming qualities. |
| tasks | **Weigh the ingredients**  Bring water up to 80 degrees C  Add glycerine and agar, stir gently to avoid bubbles  **Allow mixture to thicken**  Keep the temperature around 80C  Stir gently throughout for 30 mins  Allow water to evaporate until liquid is like light syrup  **Cast the bioplastic**  Cast the bioplastic slowly in the center of the mold  Allow to dry for a week without touching  **Release the bioplastic**  Check that the plastic no longer feels cold to the touch  Gently peel it off the surface |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  5 g Agar, 15 g Glycerine, 250 g Water  **Tools**  Scale, pot, stove, spoon, wide mold or casting surface  **Reference**  Biofabricating Materials lecture notes, by Cecilia Raspanti, Fabricademy 2019: https://class.textile-academy.org/classes/2019-20/week05A/  **See also**  Alginate bioplastic  Carrageenan bioplastic |
| Ideas for image | Agar.jpg |

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| Title | Alginate bioplastic |
| Subtitle | Gum polysaccharide found in brown algae. |
| Short description | Agar, carrageenan, and alginate are *gum polysaccharides*. As food-safe biopolymers they are used widely in the food industry as thickeners and stabilizers but they also have good film-forming qualities. |
| tasks | **Prepare the bioplastic mixture**  Weigh the ingredients  Put the glycerine and half of the water in a blender  Turn on the blender, sprinkle in the sodium alginate  When the paste is homogenous, add the remaining water  Leave the mixture overnight in a closed jar  **Prepare the cross-linker**  Put the calcium chloride in a glass jar  Add 100 g hot water and stir to dissolve  Allow to cool and transfer to spray bottle  **Cast the bioplastic**  Cast the bioplastic slowly in the center of the mold  Spray generously with calcium chloride solution  Allow to dry until no longer cold to the touch  **Releasing the bioplastic**  Gently peel off the casting surface |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  For the bioplastic: 10 g Sodium Alginate, 20 g Glycerine, 200 g Water.  For the cross-linker: 10 g Calcium Chloride, an additional 100g water.  **Tools**  Scale, blender, spray bottle, glass jar, casting surface  **Reference**  Biofabricating Materials lecture notes, by Cecilia Raspanti, Fabricademy 2019: https://class.textile-academy.org/classes/2019-20/week05A/  **See also**  Agar bioplastic  Carrageenan bioplastic |
| Ideas for image | Alginate\_film.jpg |

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| Title | Carrageenan bioplastic |
| Subtitle | Gum polysaccharide found in red seaweed. |
| Short description | Agar, carrageenan, and alginate are *gum polysaccharides*. As food-safe biopolymers they are used widely in the food industry as thickeners and stabilizers but they also have good film-forming qualities. |
| tasks | **Weigh the ingredients**  Bring water up to 80 degrees C  Add glycerine and carrageenan, stir gently to avoid bubbles  **Allow mixture to thicken**  Keep the temperature around 80C  Stir gently throughout for 30 mins  Allow water to evaporate until liquid is like light syrup  **Cast the bioplastic**  Cast the bioplastic slowly in the center of the mold  Allow to dry for a week without touching  **Release the bioplastic**  Check that the plastic no longer feels cold to the touch  Gently peel it off the surface |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  16 g carrageenan kappa, 3 g glycerine, 350 g water  **Tools**  Scale, pot, cooker, spoon, casting surface  **Reference**  Lugae Valenti, Making Carrageenan 2021: https://vimeo.com/386012184  **See also**  Agar bioplastic  Carrageenan bioplastic |
| Ideas for image | carrageenan.jpg |

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| Title | Gelatin bioplastic |
| Subtitle | Gelatin is hydrolized *collagen*: a protein found in cartilage, bone and skin of animals, which is a biopolymer. |
| Short description | Gelatin or hydrolized collagen and is found in cartilage, bone and skin of animals. It is used as a gelling agent in food, medicine and microbiology, and is used in photography and paper sizing. |
| tasks | **Weigh the ingredients**  Bring water up to 80 degrees C  Add glycerine and gelatine, stir gently to avoid bubbles  **Allow mixture to thicken**  Keep the temperature around 80C  Stir gently throughout for 10-20 mins  Allow water to evaporate until liquid is like a thick syrup  **Cast the bioplastic**  Cast the bioplastic slowly in the center of the mold  When solidified: release from the mold  Allow to dry fully for a week |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  50 g gelatine, 15 g glycerine, 250 g water  **Tools**  Scale, pot, cooker, spoon, casting surface  **Reference**  Biofabricating Materials lecture notes, by Cecilia Raspanti, Fabricademy 2019: https://class.textile-academy.org/classes/2019-20/week05A/  **See also**  Agar bioplastic  Carrageenan bioplastic |
| Ideas for image | Gelatine.jpg |

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| Title | TO DO: Chitosan bioplastic |
| Subtitle |  |
| Short description |  |
| tasks | **Weigh the ingredients** |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  **Tools**  **Reference**  **See also** |
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| Title | Mycelium-hemp composite |
| Subtitle | Composite of hemp fibres, *chitin* and other polymers |
| Short description | Mycelium is the vegetative part of the mushroom, and consists of several biopolymers such as chitin, cellulose and proteins. |
| tasks | **Clean all tools and surfaces with 70% alcohol**  **Prepare the composite mix**  Wear gloves and open the bag with clean scissors  Add the GIY mix to the bowl and mix in the flour  Crumble up all the lumps with your hands until even  **Prepare the mold**  Desinfect the mold with alcohol  Distribute the mycelium-hemp mix  Cover the mold with cling film  Punch small holes every 3 cm with a clean scalpel  **Let it grow**  Put the mix in a dark place at 20-25 degrees C  Allow the mycelium to colonize the substrate for 3-5 days  When it is completely white, carefully take it out  **Dry the composite**  Dry the composite for 2-3 hours at 40 degrees C  Keep the door of the oven open to allow moisture to escape  Bake for another 2 hours at 80 degrees until light and firm |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  GIY kit from grown.bio, plain flour (30g per kg grow kit)  **Tools**  Scale, 70% alcohol, scissors, large bowl, scalpel, cling film, latex or nitrile gloves, molds  **Reference**  Grow-It-Yourself kit via Grown.bio https://www.grown.bio ​  **See also**  Kick-start your Mycoculture by Fabtextiles https://issuu.com/nat\_arc/docs/myceliumfabtextiles |
| Ideas for image | Mycelium\_composite.jpg |

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| Title | Onion skin pigment extraction |
| Subtitle | Plant-based pigment extracted from onion skins |
| Short description | The outer skins of onions contain a pigment called pelargonidin that can be used to create a medium light fast textile dye. |
| tasks | **Separate yellow and red onion skins**  Yellow onion skins create a yellow/gold/orange hue  Red onion skins create a greens and greenish yellow  Pre-wet the mordanted fibre by putting them in water  **Cover the onion skins with water and bring to the boil**  Extract the pigment by letting it simmer for 30-60 minutes  Allow to cool to 30 degrees C  **Dyeing**  Add the pre-wetted mordanted fibres  Slowly reheat, keep temperature below 80 degrees C  Dye for 1 hour, turn off the heat and leave overnight  **Rinsing and modifying**  Rinse the fibres until the water runs clear, squeeze out excess  Cut the fibre into 4 parts. Dip one in a jar of vinegar, dip one in a soda solution (PH9-10), and dip the last one in an iron sulphate solution to shift the colors.  **Re-use or store the dye**  add new fibres to the exhaust bath, evaporate more water and add a binder such as Arabic gum to create an ink, or create a lake pigment e.g. <https://rebeccadesnos.com/blogs/journal/making-lake-pigments> |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  10-20 g Onion skins (red and yellow onions separated), 20g mordanted natural fibres, water, PH modifiers (soda solution, vinegar), iron modifier, cloves or clove oil.  **Tools**  Cooker, pot, spoon, scale, strainer, glass jar  **Reference**  ​Biochromes week (2019) Fabricademy: https://class.textile-academy.org/classes/2019-20/week04/  **See also**  Joy Boutrup & Catherine Ellis (2019) The Art & Science of Natural Dyes: Principles, Experiments.  Jason Logan (2018) Make Ink: A Forager’s Guide to Natural Inkmaking. |
| Ideas for image | onion\_dye.jpg |

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| Title | Starch bioplastic |
| Subtitle | Starch or amylum is a *polysaccharide* (or polymeric carbohydrate) produced by plants for energy storage. |
| Short description | In industry, (modified) starches are used to manufacture bioplastics, alcohol and biofuel, as thickener for e.g. sauces. Non-food applications include stiffening textiles, adhesives and papermaking. Because native starch has poor processing and mechanical properties, gelatin is added here. |
| tasks | **Prepare the gelatine mix**  Weigh the ingredients  Bring water to the boil, add the glycerine and gelatine  Keep temperature below 80 degrees C  Stir slowly until gelatine is fully dissolved  **Prepare the starch mix**  Put starch in a bowl and dissolve with 2 tbsp hot water  Add the mixture to the gelatine mix and stir slowly  **Casting and drying**  When it thickens but is still liquid, cast on surface  Quickly spread out with spatula if needed  Allow to dry at room temperature near an open window |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  50 g potato starch, 50 g gelatin powder, 100 g glycerine, 100 g water, 15 g vinegar  **Tools**  Cooker, pot, scale, spoon, casting surface  **Reference**  ​Starch-based rubber by Loes Bogers (2020) <https://class.textile-academy.org/2020/loes.bogers/files/recipes/biorubber/>  **See also**  The Bioplastics Cookbook: A Catalogue of Bioplastics Recipes by Margaret Dunne for Fabtextiles (2018) <https://issuu.com/nat_arc/docs/bioplastic_cook_book_3> |
| Ideas for image | starch\_rubber.jpg |

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| Title | Milk composite |
| Subtitle | Mammal milk contains a protein called *casein*, which is a biopolymer |
| Short description | Casein was first patented in 1899 and was used to copy horn. It was commonly used for small items such as buttons, cutlery handles and knitting needles. |
| tasks | **Preparing the casein**  Heat up the milk and add the vinegar, stir  After 1 minute: strain the casein curd from the liquid  Put in the blender and blend with glycerine  Press into mould and dehydrate fully  **Making the composite**  Wear a mask to protect airways from small particles  Grate the dried casein plastic into a fine powder  Dissolve the calcium hydroxide in hot water  Dissolve the calcium carbonate in the vinegar  Mix both with the calcium carbonate  **Casting and drying**  Cast into a mould and press for 1 hour  Dehydrate at 50 degrees C in the oven for at least 4 hrs  Allow to air dry until fully dehydrated. |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  65 g calcium carbonate or finely ground egg shells, 25 g calcium hydroxide, 8 g glycerine, 800 g low fat milk, 30 g white vinegar  **Tools**  Face mask, scale, bowls, grater, oven, cooker, pots, blender  **Reference**  ​William Christmas (1924) Casein Plastic Composite patent <https://bit.ly/3C7rdYF>  **See also**  Tessa Silva (2016) Chalk & Cheese, and Protein project: https://www.tessasilva.com/chalk-cheese |
| Ideas for image | milk\_composite.jpg |

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| Title | Fruit leather |
| Subtitle | Most fruits contain the biopolymer *pectin*, a polysaccharide |
| Short description | Fruit leather was originally conceived of as a way to preserve fruit to be eaten as a snack. To make fruit leather, overripe fruit is best, used with skin and all. Unsold market fruits are a big waste stream in the Netherlands. |
| tasks | **Prepare the mixture**  Cut the mango in smaller pieces and puree with blender  Put the puree in a pot with some water  Keep at low heat for 30 minutes while stirring to kill bacteria  **Cook the mixture**  Dissolve the starch in a dash of cold water  Add to the hot mango mixture and stir  Cast the paste into the mould  **Drying**  Heat the oven to 40-50 degrees C  Dry the sheet for 16 hours in the oven  Peel off the sheet and flip to dry the other side  Allow to airdry for another 5-7 days |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  1 overripe mango with skin, 10 g potato starch, 8 g vinegar  **Tools**  Blender, walled mould, cooker, pan, spoon, scale, oven  **Reference**  ​Beatriz Sandini (2018) Ephemeral Fashion Lab: <https://class.textile-academy.org/2020/beatriz.sandini/projects/final-project/>  **See also**  Fruit Leather, Rotterdam: https://fruitleather.nl/ |
| Ideas for image | fruitleather.jpg |

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| Title | Microbial leather |
| Subtitle | Kombucha culture contains *Acetobacter Xylinum*, a bacteria that produces pure *nanocellulose* as it ferments sugars. |
| Short description | Kombucha is a fermented tea drink that can be made with living culture called a SCOBY: symbiotic culture of bacteria and yeast. By building up this culture, you can create a small cellulose factory. |
| tasks | **Prepare your work area**  Clean and disinfect your work area and wash all tools with very hot water and soap. Rinse off the soap well  **Brew the sugary tea**  Brew 400 ml of tea, add the sugar and stir to dissolve  Allow to cool to 30 degrees C  Strain the tea and catch the liquid in the clean glass jar  **Add the living culture**  Add the kombucha culture form the starter pack (both the liquid SCOBY and the pellicle).  Add white vinegar until pH of the liquid reaches pH6  Cover the jar with a coffee filter or piece of clean t-shirt, and wrap a rubber band around it. The filter allows for oxygen to come through but keeps bugs out.  Allow the culture to go in a warm spot away from sunlight  **Wait 3-4 weeks**  Check for every few days for contamination, without moving the pot or the filter.  If the culture is contaminated (see link below), discard!  You should see a white or translucent pellicle growing on the top of the surface after a few weeks.  Wait until the pellicle is 10 mm thick  **Harvesting**  Wash your hands and tools well, take out the pellicle  Prepare a citric acid solution with pH2-3 and soak the pellicle in it overnight, this will make it more supple  Allow it to until fully dehydrated (e.g. oven at 50 degrees C)  **Continuous culturing**  Repeat the process by adding more cold sugary tea to the liquid SCOBY in the jar and wait another few weeks.  Your culture will get stronger and grow faster over time. |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  1x Yaya Kombucha starter pack (contains SCOBY), 4 g green or black tea, 40 g sugar, vinegar, 400 ml water, citric acid  **Tools**  Clean glass 1000 ml jar, dishwashing soap, PH strips, large round coffee filter or old t-shirt, rubber band  **Reference**  ​ Suzanne Lee (2011) Grow Your Own Clothes TedTalk: https://www.ted.com/talks/suzanne\_lee\_grow\_your\_own\_clothes  **See also**  Kombucha Mold! How to Identify Mold vs. No Mold and What to Do Next (n.d.) Kombucha Kamp: https://www.kombuchakamp.com/kombucha-mold-information-and-pictures |
| Ideas for image | kombucha.jpg |

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| Title | Fish leather |
| Subtitle | Fish skin is rich in the protein *collagen*, a biopolymer |
| Short description | This treatment with alcohol *denatures* or damages the living cells of the fish skin, to prevent decomposition. Glycerine re-hydrates and plasticizes the skin, making it pliable and stable. |
| tasks | **Clean the skins**  Scrape off fat, meat and membrane with a blunt scraping tool  Wash the skins with cold soapy water and rinse  **Prepare the tanning liquid**  Put the glycerine and alcohol in the jar  Submerge the skins in it and shake vigourously for 1 min  Put a little weight (like a marble) on the skin to keep it down  **Tanning process**  Keep the skins in the jar for 3 days, shake daily for 1 min  Take out the skins, massage and stretch them for 1 hr  Nail them to the wooden board and leave outside to dry |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  Fresh uncooked fish skins, 250 ml denatured 96% alcohol, 250 ml glycerine  **Tools**  Blunt scraping tool, 1000 ml glass jar, dishwashing soap, wooden board, nails, hammer  **Reference**  Fish Skin Tanning from the 6-8th grade Heritage Kit Curriculum, by Chugachmiut Heritage Preservation, Anchorage USA:​<https://chugachheritageak.org/pdf/CLO_6-12%20_FISH_SKIN_TANNING_Final.pdf>  Cecilia Raspanti (2019) Fish skin leather: <https://class.textile-academy.org/classes/2019-20/week05A/>  **See also**  Nienke Hoogvliet (n.d.) Re-Sea Me <https://www.nienkehoogvliet.nl/portfolio/re-seame/> |
| Ideas for image | fish\_leather.jpg |

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| Title | Flower paper |
| Subtitle | Plant cells in flower petals – and other parts of green plants - contain *cellulose,* a biopolymer |
| Short description | With this simple technique you can make your own paper. Stems can also be used, but need longer cooking time and result in rougher and thicker paper. |
| tasks | **Prepare the paper slurry**  Pick the flower petals from the bouquet  Cover them with water, add a tsp of soda ash  Bring to the boil and cook for 30 mins or until soft  Strain the flower leaves and pound them in the mortar  Optional: blend them with a blender, but this cuts the fibres and results in a more brittle paper.  **Distribute the slurry**  Scoop the slurry onto the mesh or mould & deckle  Spread out evenly, about 2 mm thick  Carefully submerge in water to help distribute the slurry  **Allow to dry**  Leave to dry for about 2 days  Carefully peel the paper off the mesh  Press under a stack of books or heavy object to keep flat |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  Bouquet of withered flowers, sodium carbonate (soda ash), water  **Tools**  Mortar and pestle, cooker, pot, mould & deckle or a picture frame lined with a fine mesh, strainer  **Reference**  ​ May Babcock for Paper Slurry (2014) Hand-papermaking With Plants: <https://www.paperslurry.com/2014/08/20/hand-papermaking-with-plants-illustrated-infographic/>  **See also**  https://class.textile-academy.org/2020/loes.bogers/files/recipes/flowerpaper |
| Ideas for image | flower\_paper.jpg |

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| Title | Madder pigment extraction |
| Subtitle | Like indigo (blue) and weld (yellow), madder is a *Grand Teint*: a classic dyeplant that is color fast and lightfast*.* Madder produces reds, oranges and browns. |
| Short description | Madder came from the roots of *Rubia Tinctorum* plants found in Southern Europe and West-Asia. Madder was brought to the south of the Netherlands and Flanders around 1300 where the clay soil was optimal for madder cultivation. Compared to red pigments coming from the synthetic garancine, madder is less ecologically taxing. |
| tasks | **Soak the roots**  Soak the dried madder roots in water overnight  Blend them with a blender  **Extract the pigment**  Put the roots in the pantyhose and make a knot to close  Put the madder in a pot and cover with water  Optional: adding a tbsp of soda ash and/or calcium carbonate brings out the red tones  Bring up to 60 degrees C, and keep there for 2 hours  Overheating causes pigment to shift to brown  Allow to cool, keep the madder roots for a 2nd extraction  **Use or store the pigment**  Use the pigment solution as a textile dye, or evaporate water on low heat to create a water-based ink, or create a lake pigment for DIY crayons and paints. |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  50 g dried madder roots, water  **Tools**  Pot, thermometer, cooker, spoon, old pantyhose, blender  **Reference**  ​ Joy Boutrup & Catherine Ellis (2019) The Art & Science of Natural Dyes: Principles, Experiments.  **See also**  Onion pigment extraction |
| Ideas for image | madder.jpg |

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| Title | Oak gall tannin extraction |
| Subtitle | Oak gall extractions can be used as tannin mordant to prepare textiles for dyeing, and when combined with ferrous acetate creates dark iron gall ink. |
| Short description | Oak galls form when gall wasps inject their larvae into developing buds of the oak tree. An oak gall forms as the larvae undergo metamorphosis into adults. |
| tasks | **Extracting the tannins**  Put the galls in a plastic bag and smash with a hammer  Cover with water and bring to the boil  Simmer for at least an hour to extract the tannins, strain  **Modifying the color**  When tannins are exposed to iron ions (such as DIY iron acetate) the pale yellow/beige color will turn dark gray/purple.  **Uses**  Use the extraction to dye textiles, or use a diluted extraction as tannin mordant to prepare textiles for dyeing. Or evaporate more water to turn it into a water-based ink. |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  100 g oak galls, water, DIY iron acetate  **Tools**  Plastic bag, hammer, cooker, pot,  **Reference**  ​​Joy Boutrup & Catherine Ellis (2019) The Art & Science of Natural Dyes: Principles, Experiments.  Catherine Ellis (2018) Are All Oak Galls Equal? <https://blog.ellistextiles.com/2018/08/06/are-all-oak-galls-equal/>  **See also**  DIY iron acetate (“iron vinegar”) |
| Ideas for image | oak\_gall.jpg |

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| Title | Fungal dye |
| Subtitle | Pigment from the toxic Sulphur tuft mushroom or *Hypholoma fasciculare* can be used as wool dye (and glows under a blacklight!) |
| Short description | This mushroom (NL: zwavelkop) is highly abundant in the Netherlands and can be found in groups at the foot of deciduous and conifer trees in parks and forests. |
| tasks | **Find a mycologist to help you identify the right mushrooms**  **Preparing the dye bath**  Clean the mushrooms and break them into smaller pieces  Put the pieces in a wash bag  Put the wash bag in the pot and cover with water  Bring to 80 degrees C and extract the pigment for 1 hr  Allow to cool, then add the wet mordanted wool  Dye the wool at 80 degrees C for 30-60 minutes  **Rinsing and modifying**  Take half the wool out, rinse with warm water  Add a splash of DIY iron acetate to the dye bath and modify the color of the remaining wool.  Take out the wool, rinse with warm water |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  250 g fresh sulphur tuft mushrooms, 25 g mordanted wool, DIY iron acetate  **Tools**  Large pot (non-food only), cooker, wash bag, spoon  **Reference**  ​Miriam Rice (1974) Mushrooms for Color  **See also**  DIY Iron Acetate  That Which Sustains Us: Lessons from the Forest Natural Dyeing with Mushrooms (2020) Museum of Vancouver: <https://youtu.be/o-IXeTI7AwY> |
| Ideas for image | fungaldye.jpg |

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| Title | DIY pH paper |
| Subtitle | Extract of red cabbage juice changes color when exposed to solutions of varying acidity (or pH): it is purple when neutral (pH 7-8), turns pink below pH 6, and blue/green from pH9 and up. |
| Short description | The purple color in red cabbage comes from a class of pigment molecules called anthocyanins. The level of acid or alkali (i.e., lower or higher than pH 7) around the molecule changes the color of the anthocyanin. |
| tasks | **Prepare the ink**  Grate the red cabbage  Put in the pot and cover with water  Bring to the boil and simmer for 30 mins  Strain the liquid and put in a spray bottle  Spray the purple liquid to cover the entire filter paper  Allow to dry  **Make a legend**  Boil some water and put in the bowls  Add a pinch of citric acid to one bowl, stir to dissolve  Add a pinch of soda ash to another bowl, stir to dissolve  Dip a piece of paper in each and tweak until you get the following colors: fuchsia pink (pH3-4), pink/purple (pH5-6), blue/purple (pH7-8), blue/green (pH9-10), green (pH 13-14)  Write up a legend and glue the papers to it |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  Half a red cabbage, water, citric acid, soda ash  **Tools**  Food grater, pot, cooker, a clean spray bottle, filter paper or white coffee filters, 4 bowls  **Reference**  Anne Marie Helmenstine (2020) Make Red Cabbage pH paper: <https://www.thoughtco.com/make-red-cabbage-ph-paper-605993>  **See also**  <https://class.textile-academy.org/2020/loes.bogers/files/recipes/phmodifiers> |
| Ideas for image | phpaper.jpg |

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| Title | DIY iron acetate |
| Subtitle | DIY iron acetate is also called iron vinegar or iron liquor and can by made by letting white vinegar corrode iron scraps. |
| Short description | It is high in iron ions, which react with tannins found in several natural dyes and foodstuffs. DIY iron acetate shifts colors of tannin rich dyes to greens and grays and increases color fastness of dyes when used as a mordant. |
| tasks | Put the rusty iron nails or the steel wool in the jar  Cover with vinegar  Leave for 1-3 weeks  Wear household gloves before using  Can be used as mordant, dye modifier or wood stain.  Use only small – diluted - amounts, the iron is corrosive to fibres and irritant to eyes and skin. |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  White vinegar, rusty iron nails or a fine steel wool sponge  **Tools**  Large glass jar, house hold gloves  **Reference**  Make Wood Stain (n.d.) <https://www.apieceofrainbow.com/make-wood-stain/>  **See also**  Oak gall tannin extraction  Fungal dye |
| Ideas for image | iron\_nails.png |

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| Title | Scouring and mordanting wool fibres |
| Subtitle | Scouring and mordanting wool (protein fibre) to prepare it for textile dyeing with natural dyes. |
| Short description | Scouring is a method of cleaning the fibres. Mordants are typically mineral salts that are applied to natural fibres before dyeing, to improve dye uptake and light and wash fastness. |
| Tasks | **Scouring**  Soak the fibres in water overnight  Dissolve the detergent in hot water  Put the wool in a large pot, add the solution and cover with water until the wool can float freely  Bring up to 80 degrees C and keep there for 30 mins  Allow to cool a little and rinse with warm water  **Mordanting**  Measure the alum and cream of tartar, and put in the jar  Add some boiling water and stir to dissolve  Put the fibres in a large pot, add the solution  Cover the fibres with additional water so they float freely  Bring the fibres to 80 degrees C, slowly  Turn off the heat and leave overnight  Squeeze out excess water, rinse lightly  Replenish the mordant bath by adding 50% to re-use |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  100 g wool (dry weight), 1 g mild detergent, 15 g alum, 5 g cream of tartar, water  **Tools**  Large pot, cooker, glass jar, scale, spoon, bucket, thermometer  **References**  How to Scour (n.d.) Botanical Colors: <https://botanicalcolors.com/how-to-scour/>  Joy Boutrup Catherine Ellis (2018) The Art & Science of Natrual Dyes: p. 120-121.  **See also**  Scouring and mordanting silk fibres  Scouring and mordanting cellulose |
| Ideas for image | mordanting\_wool.jpg |

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| Title | Scouring and mordanting silk fibres |
| Subtitle | Scouring and mordanting silk (protein fibre) to prepare for textile dyeing with natural dyes. |
| Short description | Scouring is a method of cleaning the fibres. Mordants are typically mineral salts that are applied to natural fibres before dyeing, to improve dye uptake and light and wash fastness. |
| Tasks | **Scouring**  Soak the silk in water overnight  Dissolve the detergent in hot water  Put the silk in a large pot, add the solution and soda  Cover with water until the wool can float freely  Bring up to 80 degrees C and keep there for 30 mins  Allow to cool a little and rinse with warm water  Add vinegar to the rinse water and leave for 20 mins  Rinse again, squeeze out excess water  **Mordanting**  Measure the alum, and put in the jar  Add some boiling water and stir to dissolve  Put the fibres in a large pot, add the solution  Cover the fibres with additional water so they float freely  Bring the fibres to 80 degrees C slowly  Turn off the heat and leave overnight  Squeeze out excess water, rinse in hot water  Replenish the mordant bath by adding 50% for re-use |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  100 g silk (dry weight), 1 g sodium carbonate (soda ash), 1 g neutral detergent, 15 g alum, water, 5 g vinegar.  **Tools**  Large pot, cooker, glass jar, scale, spoon, bucket, thermometer  **References**  How to Scour (n.d.) Botanical Colors: <https://botanicalcolors.com/how-to-scour/>  Joy Boutrup Catherine Ellis (2018) The Art & Science of Natrual Dyes: p. 124.  **See also**  Scouring and mordanting wool fibres  Scouring and mordanting cellulose fibres |
| Ideas for image | mordanting\_silks.jpg |

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| Title | Dyeing cellulose fibres |
| Subtitle | Scouring, mordanting and dyeing cellulose fibres (linen, cotton, hemp, ramie) |
| Short description | Scouring is a method of cleaning the fibres. Cellulose mordants typically start with application of tannins followed by mordanting with mineral salts before dyeing, to improve dye uptake and light and wash fastness. |
| tasks | **Scouring**  Fill a large pot with warm water  Add and dissolve 1 g detergent and 1 g soda ash  Measure pH, add soda until it reaches pH8-9  Add fibres and cover with water, fibres should move freely  Heat to 100 degrees C (boil), keep there for 1-2 hours  Move the textiles regularly  Allow to cool in the mordant bath, then rinse well  **Application of tannins**  Fill a large (30L) pot with hot water (50 degrees C)  Add the tannin powder and stir until dissolved.  Add the fibres and soak for 2 hrs. Do not heat the bath.  Remove fibre, squeeze out wearing gloves  While still damp: proceed to alum mordant  **Alum mordanting**  Dissolve the alum in boiling water, allow to cool  Dissolve the soda in boiling water, allow to cool  Combine the alum and soda solution, while stirring  Add enough warm water (50 degrees C) to immerse fibres  Place moist tannin-treated fibres in mordant, soak for 2 hours  Stir occasionally, then take out wearing gloves  Squeeze our excess mordant and rinse well. |
| \*ingredients  \*tools \*reference \*see also | **Ingredients**  100 g cellulose fibres, 1 g soda ash and 1 g detergent for scouring, 10 g oak gall extract OR: 30 g ground oak galls, 12 g alum and 1.5 g soda ash for mordanting.  **Tools**  Large pot, cooker, glass jar, scale, spoon, bucket, pH paper, rubber gloves  **References**  How to Scour (n.d.) Botanical Colors: <https://botanicalcolors.com/how-to-scour/>  Joy Boutrup Catherine Ellis (2018) The Art & Science of Natrual Dyes: p. 117, 127, 132.  **See also**  Scouring and mordanting silk fibres  Scouring and mordanting wool fibres |
| Ideas for image | mordanting\_cellulose.jpg |

## Critical Making

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| **title** | (Un)making the mold |
| Short description | Consumer electronics are often encased by injection-molded thermoset plastics that long outlast their actual time of use. Challenge these archetypes by using materials and processes that allow for organic distortions and unexpected results. |
| tasks | **Dissect a product**  Select a (broken) consumer electronics product  Take it apart and study the electronics and its functions  Make a visualization of your dissection  **Develop your own mold**  Choose a biomaterial to work with (see recipe cards) Make a mold – to create new casing for the electronics  Test it out by casting the material and allow it to dry (1 week)  **Testing and refining**  Set new goals and iterate on your mold and method  Document the process and results, share with class |
| when/why/note/output/next | **Tips**  Consider these parameters: compatibility between materials of mold and material being molded | accommodate need to apply pressure | accommodate need for ventilation | accommodate absorption of excess material onto a “bleeder” or sacrificial layer | release angles and release agents | warping and shrinkage  **Next**  Draw your mold design in a CAD program (e.g. Rhino)  Fabricate your design and cast models in different materials |
| Reference | Jeongwon Ji (2013) BioElectric <https://www.dezeen.com/2013/07/01/bioelectric-plastic-made-of-crab-shells-by-jeongwon-ji/> |
| See also | Basics Mold Making (n.d.) Smooth-on <https://www.smooth-on.com/howto/basics-mold-making/> and How to Make Molds (n.d) Instructables: <https://www.instructables.com/How-to-make-molds> |
| Ideas for image | umaking-mold2.png caption: BioElectric by Jeongwon Ji (2013) |

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| **title** | Being a 3D printer Execute your own Gcode to defamiliarize your making process |
| Short description | Being the Machine is an alternative 3D printing process that operates in terms of negotiation rather than delegation. It takes Gcode (the instructions typically provided to 3D printers) and presents them to human makers to follow. |
| tasks | Prepare by reading Devendorf & Ryokai’s article  Follow a laser with a pencil to draw paths on paper (15 mins)  **Build**  Select a 3D model to build (e.g. on Thingiverse)  Express any desires you have to modify the design  Select an everyday, abundant material to work with  Put the model in a slicer, and find the path viewer  Person 1 traces the gcode paths with the laser  Person 2 follows the laser by “printing” the paths with the chosen material  There’s no right or wrong, only negotiation  **Reflect**  How did you decide on the material selection?  Can you describe the experience of working with the system?  When did you deviate? Why?  What did you learn about working with this material?  Describe the features of your object |
| when/why/note/output/next | **Why**  Subverting an expected relationship between humans and machines in making 1) helps explore the *semiotic effects* that are produced when different materials, contexts, and processes are brought into juxtaposition with one another and 2) helps create understanding of a medium on both *symbolic* and *technical* levels.  **Output**  Users negotiate control between themselves, the system, and their materials in order to enter into meditative, reflective, and collaborative modes of making.  **Next**  Develop your own 3D printing paste by modifying one of the bioplastics recipes, and repeat the exercise with your pastes. |
| Reference | Laura Devendorf and Kimiko Ryokai. 2015. Being the Machine: Reconfiguring Agency and Control in Hybrid Fabrication: <https://dl.acm.org/doi/abs/10.1145/2702123.2702547> |
| See also | Recipe cards |
| Ideas for image | 3Dprinter.png |

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| title | Demystifying biotechnology |
| Short description | Biotechnologies (from the Greek ‘bios’ or life and ‘technikos’ or use) are methods that make use of ‘life’ for practical objectives, from making cheese to genetic modification. |
| Tasks | Biotechnology has been around for thousands of years ago when nomads accidentally made cheese by transporting milk in cow stomachs. We now know the enzymes and bacteria can turn the milk into cheese. We often think of it as being very *high-tech* inventions, like cloning sheep. Maybe they are both, and it’s often just a matter of time for them to become commonplace?  **Find high-tech examples**  With your class, come up with 100 examples of *high-tech* biotechnologies  **Find low-tech examples**  Try to find another 100 examples of biotechnologies that you may encounter in your everyday life. They are everywhere, keep looking!  **(Do-Not)-Do-It-Yourself?**  Watch this video about biohacking: <https://youtu.be/fV-Edkh1iqE>  Explore these two kits: <https://amino.bio/collections/genetic-engineer-101> and <https://www.the-odin.com/gene-engineering-kits/>  Some argue that biotechnology should be democratized, others mostly see dangers. Unlike in some other countries, such practice strictly controlled in the Netherlands: use of these kits without a permit is illegal in the Netherlands.  **Design a speculative DIY kit for a biotechnology**  Pick one of the biotechnologies from your high-tech list and design what a DIY kit might look like and how it would be marketed. Use your prototype to talk to people about biohacking, and what their opinions are. Share the results. |
| when/why/note/output/next |  |
| Reference |  |
| Ideas for image | demystifying\_biotech.png >> credit: Amino.bio |

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| **title** | Shit, Hair, D(isg)ust Taboos around things we consider to be out of place |
| Short description | Human and biological waste are abundant, sustainable feedstocks for material-making. Negative connotations around shit, hair and dust however and our perceptions of beauty need to shift for these materials to become acceptable (again). |
| Tasks | Study the projects listed below:  Merdacotta & the Shit Museum (2015-ongoing) by Gianantonio Locatelli & Luca Cipelletti: <http://www.theshitmuseum.org/prodotti/>  <https://materialdistrict.com/material/merdacotta/>  The New Age of Trichology (2016-ongoing) by Sanne Visser: <https://sannevisser.com/The-New-Age-of-Trichology>  How Dust This Feel? (2015) by Matilda Beckman: <https://www.dezeen.com/2015/02/06/matilda-beckman-furniture-made-from-dust-stockholm-2015/>  Discuss the following questions:  Which ideas, beliefs, and value systems are in place regarding the materials these artists and designers work with?  Which strategies do the makers use to shift our perspective towards these materials?  Are they successful in shifting your perspective on waste? Why/why not?  Find a material in your environment that is typically considered dirty or disgusting but could have interesting qualities to work with. Develop a strategy that helps shift peoples’ perspective on and connotations with that material. |
| Why when note | **Why**  Reappropriating waste materials to create art and design objects asks us to reconsider our own and others’ ideas about dirt and cleanliness, and about waste and newness.  **When**  After you have tried out some bio-based material recipes and realize that making materials out of food grade ingredients might be unnecessary and unsustainable, and want to start looking elsewhere. |
| Recommendations |  |
| References | Mary Douglas (1966) Purity and Danger.  Kate Franklin & Caroline Till (2018) “Shit, Hair, Dust” in: Radical Matter: Rethinking Materials for a Sustainable Future: p. 75-107. |
| Ideas for image | hair\_denise.jpg |
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| **title** | Biodata processing Give a voice to living organisms |
| Short description | Can we communicate with other biological life forms other than animals? Read electrical signals (biodata) from plants and mushrooms to generate biodata-based visualizations and sounds with the Processing framework. |
| Tasks | **Download Arduino IDE and Processing IDE software, and code from Github**  <https://www.arduino.cc/en/software>  <https://processing.org/download>  <https://github.com/dnllvrvz/BioData-Exploration> by Danilo Vaz  Go to: Code > Download .ZIP  **What you need**  An Arduino-compatible prototyping board, a 10K resistor, short jumper wires and longer ones for probing  **Read data with Arduino, store it using Processing**  Open the file “SaveData” and copy lines 1-12 to an empty Arduino sketch.  Copy lines 13-91 to an empty Processing sketch.  Look up the address of the Arduino board’s active serial port (> Tools > Serial Port). Then find the line that says:  myPort = new Serial(this, "/dev/cu.usbmodem1421", 9600);  Replace the address starting with “/dev….” with the location of yours.  Run the Processing sketch and record data using the probes you connected.  **Visualize and sonify**  Open the file “finalcodecoursera” in Processing. Follow the instructions in the comments. Tinker with the code and create your own visualization/sonification of the plant data. What do you imagine plants communicate about? What could be ways to express that in the visualization/sonification? |
| when/why/note/output/next | **why**  Plants and fungi are sentient creatures, but modern societies seem to disregard this fact, perhaps because we lack a common language to establish communication between humans and non-humans. How can we begin to imagine communicating with other living beings besides animals?  **Note**  This exercise requires a basic understanding of the Arduino and Processing frameworks. If you are not familiar yet, take some more time to familiarize yourself and look at documentation and examples. |
| Reference | Assignment and materials by Danilo Vaz: <https://github.com/dnllvrvz/BioData-Exploration>. |
| Ideas for image | biodata\_processing\_teunis.png >> credit teunis |

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| title | Developing a bio art or biodesign project |
| Short description | After having explored the field a little, you might have found an area of interest to explore more in depth. How might you approach project development? |
| Tasks | Envision a (near-)future application of biotechnology. Decide on a timeline with milestones and other conditions fitting your situation. Some tips:   * Do the research. Read up on the issues so you can be precise about the problems you are addressing. What cultural issues are you responding to? Are you posing a solution or raising a question? Are you focused on a solution for today or speculative future applications and scenarios? Whatever the case, try to understand the scientific evidence of the possibilities, either by reading or by speaking to experts, to argue for the feasibility of the ideas. * If your project is speculative of critical, formulate a diagnosis of the problems you identify. What are its problems? What underlying structures and systems keep it in place? How does your project address this? Does it pose a solution or call to action? * Identify the communities your design will serve and include. Can you find ways to give voice to this target community and its unique aspects? Design *with* these people rather than *for* them. * Challenges and mistakes have a place in your project, they can lead to good insights and feedback. When presenting your process: share both accomplishments and shortcomings of your progress. * Record your thought process and reflect on it often. Ask others to help you identify biases, assumptions, and values (implicitly) at work in your project. Assess which ways you are speaking and thinking from a place of privilege that might disadvantage others or overshadow their needs. |
| why/when/note/output/next | *When*  As you develop a project in the field of bio art or biodesign.  *Note*  Keeping a process book or diary is tremendously helpful in taking some distance from what you are doing day to day. It helps you find perspective. |
| Reference | Adaptation from: “Questions to Consider as you Develop your BDC Project”, Biodesign Challenge. <https://www.biodesignchallenge.org/> |
| See also |  |
| Ideas for image |  |

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| **title** | Glossary of Bio-everything |
| Short description | Defining a shared vocabulary helps you understand the field and the terms used to describe it so you can position your own work. Craft a shared vocabulary and create a – printed – glossary of bio-everything together. |
| tasks | Make groups, and assign the word sets described below.   * Biology | Microbiology | Mycology * Biodesign | Bioart | Biofabrication * Biodegredable | Biorenewable | Biocompostable * Synthetic biology | Biohacking | Bioethics * Biotechnology | Biomimicry | Bioremediation * Bio-based materials | Biomaterials | Biomass   *For each* word or “lemma” of your glossary, find at least one example from each of the following areas: fine arts | popular culture and literature |scientific publications | everyday life | laws and regulations.  Make a mind map for each lemma, including the examples you found.  Put away your phones and laptops and discuss the keywords based on the examples and formulate your own definitions of what they each mean, based on the mindmaps you made (no internet allowed).  Document your definitions in a shared text document.  Each person creates an image for one of the each keywords/lemmas  Compile it all into a booklet and print your shared Glossary of Bio-everything. |
| Recommendations | Bonus: make the book with atypical materials that fit the topic(s): <https://www.pbs.org/video/make-a-book-with-meat-or-other-atypical-materials-e428h8/> |
| Ideas for image | glossary\_anthony.png |

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| title | A history of design & nature |
| Short description | Ideas and knowledge are constructed, and come about under the pressures of culture, (geo)politics, economics, and historical legacies of what qualifies as “knowing”. Explore the history of ideas around design & nature. |
| Tasks | 1. Select a biodesign or bioart project that inspires you 2. Read Louise St. Pierre’s text 3. Assess whether the project you selected is more aligned with the *mechanistic* or the *organicist* view of ecology (see below). 4. Present your argument in the form of an essay, a diagram, image, poem or other. 5. Take the same topic as your chosen project, and develop an activity taking the opposite approach.   **Mechanistic view of ecology**:  Ecological design as mastery  *Keywords: human-centric (solving human problems), mastery, rationality, economic growth, emotional and intellectual distance, perfection, nature as passive/controlled/mute, colonialism*  **Organicist views of ecology**  Design and nature as experiential exploration  *Keywords: spiritual, philosophical, embodied/physical explorations, ritualistic, humility, interdependence, intimacy, vulnerability, slow design, practices of care, capacity of nature to organize itself, decolonizing* |
| why/when/note/output/next | **Note**  St. Pierre’s text describes how designers throughout history have been searching for ways to design with nature. She organizes them by looking at the way ecology is understood in the different design frameworks since the 1500s.  **Why**  Understanding this old search provides designers, artists, academics with a number of frameworks and spaces to *rehearse, critique* and *learn* to work with nature and position their work. |
| Reference | Louise St. Pierre (2019) “Design and Nature: a History” in: Kate Fletcher, Louise St. Pierre & Mathilda Tham (eds.) Design and Nature: A Partnership: p. 92-108. |
| Ideas for image | westernideas.JPG |

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| title | Designed to disappear The possibility of ephemeral colour as strength |
| Short description | We tend to see durability and consistency as conditions for products. These expectations push us toward energy intensive, and often toxic processes. What if we framed ephemerality and imperfections as strengths? |
| Tasks | * Research natural pigments and dyes (references below). Learn how to prepare protein and cellulose fabrics for dyeing. * Pick one natural pigment and use it to dye some protein and cellulose swatches, make sure you have two of each, measuring 10x10cm. Label everything so you can remember what’s what. * Optional: if you have enough material, put a second batch of swatches (again, sets of two) into the leftover bath, i.e. the exhaust bath. * Bring your swatches to class and exchange one set of samples to a class mate. Take theirs home and overdye their samples with your dyestuff. * Cover part of each sample with some cardboard and hang it in a window for at least a month. * Bring the results to class and study each other’s results * Develop a textile product that uses the changing qualities of one or more pigments/dyes in such a way that it adds quality to the experience of the product. |
| why/when/note/output/next | Next  Expand the idea of ephemerality beyond color, and go through the same process for a different kind of “unstable” material. |
| Reference | Levende Kleuren (2013-2015) Report of SIA Raak research project. Avans Hogeschool. <https://www.avans.nl/onderzoek/projecten/detail/levende-kleuren> |
| See also | Joy Boutrup & Catherine Ellis (2019) The Art & Science of Natural Dyes: Principles, Experiments.  Jenny Dean’s Wild Colour (ongoing) Jenny Dean: <https://www.jennydean.co.uk>  Wildcolours (ongoing) Teresinha Roberts: [www.wildcolours.co.uk](http://www.wildcolours.co.uk) |
| Ideas for image |  |

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| title | Waste walk Identify unused sources of biomaterials that can be turned into materials of value for art & design. |
| Short description | Going on a waste walk helps you explore untapped local waste streams and helps to unlearn our habit of working with virgin materials |
| Tasks | Split up into groups and decide on a location where you will do the waste walk  Walk around the area for 2 hours, and identify any waste streams of biological origin (i.e. natural materials) you encounter. Take a picture of each of them.  Start in your home and expand outwards:   * Start in your kitchen (the fridge, your waste bin, maybe your garden or balcony) * Expand to your neighbourhood, include streets, parks, even shopping streets. * Look at plants and trees and identify which parts they shed and when (e.g. leaves, branches), both naturally and through maintenance (e.g. mowing, pruning) * Go into food shops like fish mongers and cafes to ask about the type of waste they produce a lot of (e.g. coffee waste, stale bread, fish skins, overripe fruit, fruit skins, and so on)   Make a catalogue of all the potentially useful waste streams you identified, and research historical crafts techniques that make use of them. Think of: basket weaving branches, paper-making, fish leather tanning or combining materials into composites. Use the references below for inspiration.  Optional: try out some of the techniques you found. |
| why/when/note/output/next | **Why**  Learn to identify unused sources of biomaterials that can be turned into materials of value for artmaking and design.  **When**  Autumn is typically a good season to do waste walks  **Output**  A catalogue of potential local waste streams and their uses |
| Reference | Kate Franklin & Caroline Till (2018) Radical Matter: Rethinking Materials for a Sustainable Future  Seetal Solanki, ed. (2018) Why Materials Matter: Responsible Design for a Better World. |
| Ideas for image | wastewalk.png |

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| title | Beyond biomimicry More-than-human collaborations |
| Short description | Human-centred design methods led us into the Anthropocene. We need to develop approaches that are more in tune with biological systems. |
| Tasks | Design practice have proven to be destructive to our ecologies. As an antidote, come up with a design process where you collaborate with a living organism. Find an angle that doesn’t merely imitate nature, but aims to enhance ecological performance in the long term.  Refer to the references and examples for background information and inspiration.  Sketch out or realize the system of collaboration and build an argument for why it contributes to the health of our ecosystems. |
| why/when/note/output/next | **Why**  Colloborating with living systems forces you to try to understand the interrelations at work in our ecologies. How can you act within those dynamic processes without playing god?  **Note**  Reflect on the amount of control you exert on the biological processes at work. Could you exert less control in order to give the organism more agency and live its best life? If the organisms could advocate for its needs, what would they be? |
| Reference | Bill Myers (2012) “Beyond Biomimicry” in: Biodesign: Nature, Science, Creativity: p. 10-17. |
| See also | Edhv(2010) *Debug*. Poster designs and chair created in collaboration with ants. <https://www.edhv.nl/design-lab/projects/debug/>  Diana Scherer (ongoing) *Interwoven*: <http://dianascherer.nl/>  TCBL labs & Waag (2016-ongoing) *Bioshades*. Textile-dyeing with bacteria. <https://bioshades.bio/> |
| Ideas for image | morethanhuman.png |

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| title | Cross-disciplinary reading |
| Short description | Subtitle: Perspectives on the kingdom of fungi  To understand any topic holistically, it can be enlightening to read texts expressing very different perspectives on an area. What can different disciplinary lenses show you? |
| Tasks | In this example you study the topic of fungal reproduction through three disciplinary lenses: DIY biology, anthropology and material science. All texts talk about the potential of mycelium, but they do so in very different ways. Describe the framing implicit in these texts, and discuss the extent to which they differ and overlap.  Reading questions to try answer together:   * Who are they writing for? * What prior knowledge is implied? * What is the scope of their respective studies of these fungal systems? * Finish this sentence: *“Author …[insert name]… studies the fungal systems by…..[activity]…. In doing so, the author wants to understand the ….. and ….. of …… fungi and what this means/what are the possibilities for …..* |
| why/when/note/output/next | **When**  When you are about to embark on a journey at the intersection of disciplines.  **Why**  Get an understanding of the different lenses different disciplines take, and what each of them allows us to see. |
| Reference | McCoy, Peter. “Chapter 8: Working With Fungi” in: Radical Mycology: A Treatise on Seeing and Working with Fungi. Portland: Chthaeus Press, 2016 (1985): pp. 201-223 or beyond.  Anna Lowenhaupt Tsing (2015) “Interlude: Tracking” in: The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins: p. 136-144.  Haneef, Muhammad et.al. “Advanced Materials From Fungal Mycelium: Fabrication and Tuning of Physical Properties” Scientific Reports, (7), 2017: pp. 1-11. |
| Ideas for image | crossdisciplinaryreading.jpg (Wikimedia,Tobi Kellner 2012) |

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| title | TO DO? Bioremediation |
| Short description |  |
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