BIOMATERIALS TEACHING TOOLKIT

A TEACHING RESOURCE FOR CRITICAL MATERIALS RESEARCH

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.

This toolkit will provide you ways to see materials anew, by learning more about them, exploring alternatives, or altogether de-familiarizing 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 bio-manufactured 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 help 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.

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, Cecilia Raspanti
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Many thanks to all our students for their wonderful participation, crazy ideas and honest feedback.

A digital version of the toolkit is available for download at: https://github.com/loesjebo/biomaterials_toolkit

Amsterdam University of Applied Sciences

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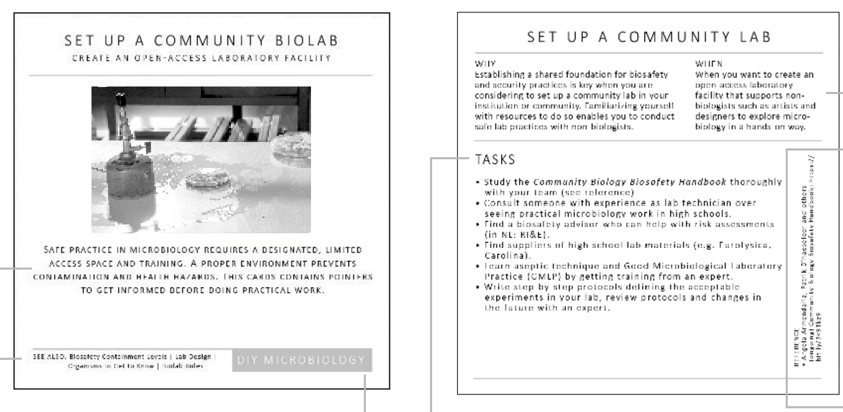
textilelab amsterdam

SELECT AND EXPLORE



INTRODUCTION
The short description allows you to quickly assess whether the activity or method on the cards suits your needs.

SEE ALSO
Cards that are related to this card: information that is needed before executing this card, additional information or cards that are about a related topic.

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, DIY Microbiology, Bio-based Materials, or Critical Making.

RECOMMENDATIONS
These sections provide context and additional information to understand and execute the tasks described on the cards.

REFERENCE
The source of the described activity. The information about the activities described on the cards is (a of times) freely available on the internet.

TASKS
The steps that need to be taken in order to execute the activity or method.

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 at will to create longer programs in higher education, based on audience, level, resources, and time available.

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.

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*
- *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.

BIOBASED MATERIALS

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.

CRITICAL MAKING

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.

MATERIOLOGY

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 give material more extensively.

DIY MICROBIOLOGY

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.

DISCLAIMER

This toolkit is presented solely for educational and entertainment purposes. The authors and publisher do not offer it as professional services advice. The best efforts were made in preparing this book, 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 merchant- ability 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 – sodium 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.*

CARD SET OVERVIEW

ALL 62 CARDS IN THIS KIT

BIO-BASED MATERIALS

Agar bioplastic
Alginate bioplastic
Carrageenan bioplastic
Gelatine bioplastic
Chitosan bioplastic
Starch bioplastic
Milk composite
Mycelium-hemp composite
Fruit leather
Microbial leather
Fish leather
Flower paper
Madder pigment extraction
Onion skin pigment extraction
Oak gall tannin extraction
Fungal dye
DIY pH paper
DIY iron acetate
Scouring & mordanting wool fibres
Scouring & mordanting silk fibres
Scouring & mordanting cellulose fibres
Better together: combining polymers
Morphology of ingredients

DIY MICROBIOLOGY

Microbial dye
Microorganisms to get to know (2x)
Biolab rules
Handwash experiment
Biosafety: containment levels
Set up a community biolab
Lab design
Cone of protection
Aseptic techniques
DIY applied mycology
Morphology of tools

SEE OTHER SIDE

CARD SET OVERVIEW

ALL 62 CARDS IN THIS KIT

MATERIOLOGY

What is a material property?
What is a materials experience?
Tactility video
Material-objects
Collaborative open-source archiving
Install a sample management tool
Define your eco-compatibility principles
Mono-material connections
Recycling
Extractive manufacturing
Additive manufacturing
Moulding & casting
Transforming
Assembling
Finishing

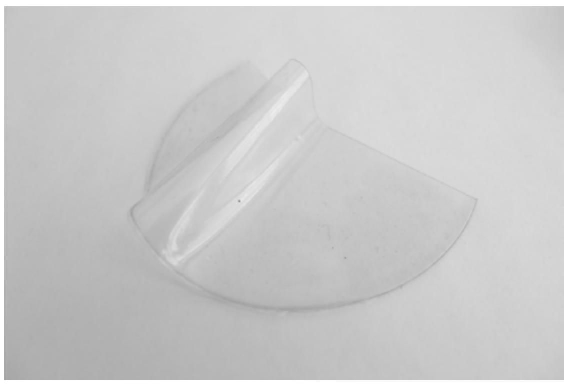
CRITICAL MAKING

Glossary of bio-everything
Demystifying biotechnology
A history of design and nature
Designed to disappear
Waste walk
Beyond biomimicry
Cross-disciplinary reading
Shit, hair, d(isg)ust
(Un)making the mould
Being a 3D printer
Biodata processing
Developing a bio art or design project

SEE OTHER SIDE

AGAR BIOPLASTIC

GUM POLYSACCHARIDE FOUND IN RED ALGAE



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.

SEE ALSO: Agar bioplastic | Carrageenan bioplastic

BIO-BASED MATERIALS

AGAR BIOPLASTIC

INGREDIENTS
5 g Agar, 15 g Glycerine, 250 g Water

TOOLS
Scale, pot, stove, spoon, walled mould

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

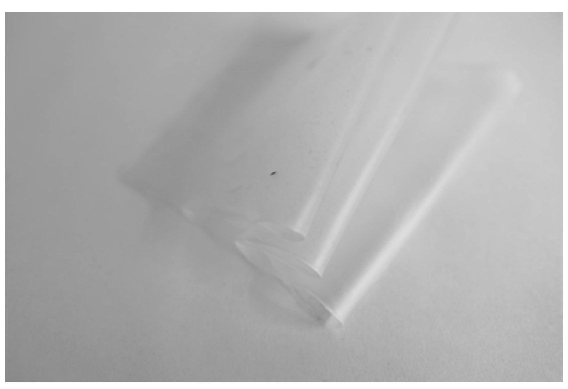
Cast the bioplastic
- Cast the bioplastic slowly in the center of the mold (3-5 mm thick)
- Allow to dry for a week without touching

Release the bioplastic
- Check that the plastic no longer feels cold to the touch
- Gently peel it off the surface

REFERENCE
• Biofabricating Materials lecture notes, by Cecilia Raspanti, Fabricademy 2019: https://class.textile-academy.org/classes/2019-20/week05A/

ALGINATE BIOPLASTIC

GUM POLYSACCHARIDE FOUND IN BROWN ALGAE



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.

SEE ALSO: Agar bioplastic | Carrageenan bioplastic

BIO-BASED MATERIALS

ALGINATE BIOPLASTIC

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

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 ***fast!***
- 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

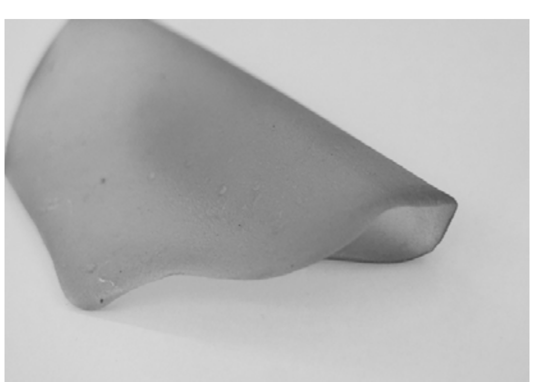
Cast the bioplastic
- Cast the bioplastic slowly in the center of the mold
- Spray generously with calcium chloride solution
- Allow to dry until no longer cold to the touch

Releasing the bioplastic
- Gently peel off the casting surface

REFERENCE
• Biofabricating Materials lecture notes, by Cecilia Raspanti, Fabricademy 2019: https://class.textile-academy.org/classes/2019-20/week05A/

CARRAGEENAN BIOPLASTIC

GUM POLYSACCHARIDE FOUND IN RED SEAWEED



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.

SEE ALSO: Agar bioplastic | Alginate bioplastic

BIO-BASED MATERIALS

CARRAGEENAN BIOPLASTIC

INGREDIENTS
16 g carrageenan kappa, 3 g glycerine, 350 g water

TOOLS
Scale, pot, cooker, spoon, casting surface

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

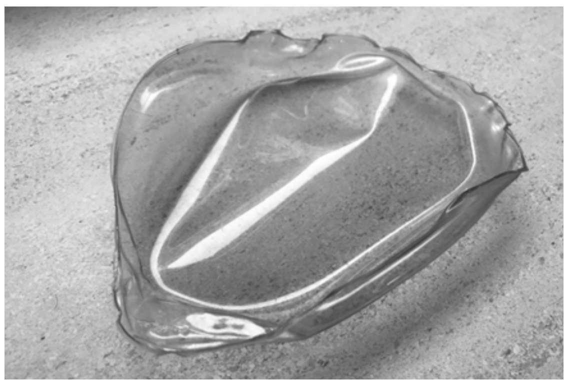
Cast the bioplastic
- Cast the bioplastic slowly in the center of the mold
- Allow to dry for a week without touching

Release the bioplastic
- Check that the plastic no longer feels cold to the touch
- Gently peel it off the surface

REFERENCE
• Lugae Valenti, Making Carrageenan 2021: https://vimeo.com/386012184

CHITOSAN BIOPLASTIC

DEACETYLATED CHITIN IS FOUND IN FUNGI AND CRUSTACEAN SHELLS



Chitin is suggested to be the second most abundant polysaccharide on earth (after cellulose) and can resist relatively high heat and has antifungal properties.

SEE ALSO: Gelatine bioplastic | Agar bioplastic | Alginate bioplastic

BIO-BASED MATERIALS

CHITOSAN BIOPLASTIC

INGREDIENTS
8 g chitosan, 200 ml water, vinegar or citric acid solution
* If adding glycerine, add no more than 1% of total weight.

TOOLS
pH strips, blender, acrylic or glass sheet for casting

TASKS

Weigh the ingredients
- Add vinegar or citric acid solution to the water until it reaches pH4-5
- Put water/vinegar mix in the blender, turn it on
- From the top lid, add the chitosan quickly in one movement while it blends

Allow mixture to thicken
- The mixture will thicken as the chitosan dissolves in the acid water
- Leave overnight to allow bubbles to disappear

Cast the bioplastic
- Cast on walled acrylic sheet: 3-5 mm thickness (will shrink a lot)
- Allow the water and vinegar to evaporate completely over the course of a few days (optional: place in oven at 60 degrees C).
- When dry: peel the sheet off the casting surface.

Shellworks has developed interesting techniques to create other forms (see video in reference).

REFERENCE
- Shellworks (2019) https://youtu.be/QBQyMjL3yWk

MYCELIUM-HEMP COMPOSITE

COMPOSITE OF HEMP FIBRES, ***CHITIN*** AND OTHER POLYMERS

Mycelium is the vegetative part of the mushroom, and consists of several biopolymers such as chitin, cellulose and proteins. It is used here as a living binder to create a composite material.

SEE ALSO: DIY applied mycology | Moulding and casting | Microorganisms to get to know

BIO-BASED MATERIALS

MYCELIUM-HEMP COMPOSITE

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, moulds

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

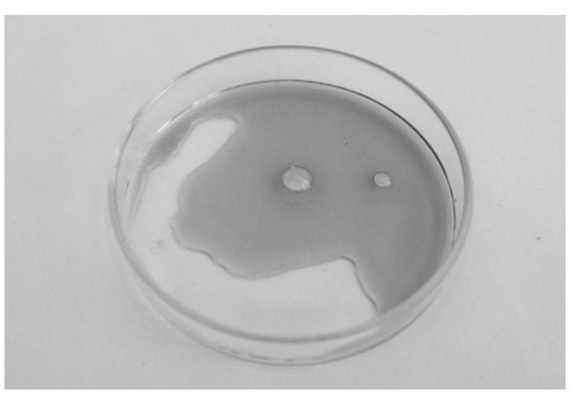
Dry the composite
- Dry the composite for 2-3 hours at 40 degrees C
- Keep the door of the oven open to allow moisture to escape
- Bake for another 2 hours at 80 degrees until light and firm

REFERENCE
- Grow-It-Yourself kit via Grown.bio https://www.grown.bio

NEXT
Learn to make mycelium composites from scratch with the following resource: Kick-start your Mycoculture (2019) by Fabtextiles https://issuu.com/nat_arc/docs/myceliumfabtextiles

ONION SKIN PIGMENT EXTRACTION

PLANT-BASED PIGMENT EXTRACTED FROM ONION SKINS



The outer skins of onions contain a pigment called pelargonidin that can be used to create a medium light fast textile dye.

SEE ALSO: Scouring and mordanting wool fibres | Scouring and mordanting cellulose fibres.

BIO-BASED MATERIALS

ONION SKIN PIGMENT EXTRACTION

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

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 fibres 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 Celcius

Dyeing
- Add the pre-wetted mordanted fibres
- Slowly reheat, keep temperature below 80 degrees Celcius
- Dye for 1 hour, turn off the heat and leave overnight

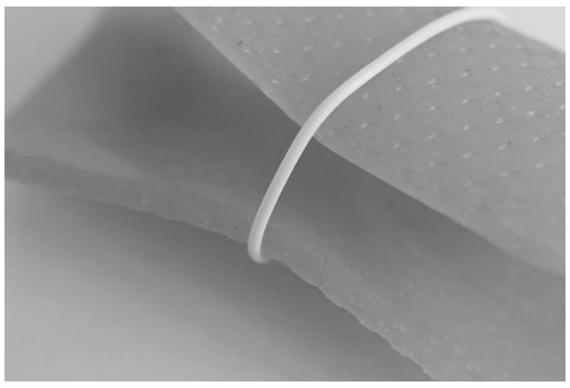
Rinsing and modifying
- Rinse the fibres until the water runs clear, squeeze out excess
- Cut the fibre into 4 parts. Dip one in a jar of vinegar, dip one in a soda solution (PH9-10), and dip the last one in an iron sulphate solution to shift the colors.

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)

REFERENCE
- Biochromes week (2019) Fabricademy: https://class.textile-academy.org/classes/2019-20/week04/
- 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.

STARCH BIOPLASTIC

POLYSACCHARIDE (OR POLYMERIC CARBOHYDRATE) PRODUCED BY PLANTS FOR ENERGY STORAGE



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 paper-making. Because native starch has poor processing and mechanical properties, gelatin is added here.

SEE ALSO: Better together: combining polymers | Gelatine bioplastic | Morphology of ingredients.

BIO-BASED MATERIALS

STARCH BIOPLASTIC

INGREDIENTS	TOOLS
50 g potato starch, 50 g gelatin powder, 100 g glycerine, 100 g water, 15 g vinegar	Cooker, pot, scale, spoon, casting surface

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

REFERENCE
- Starch-based rubber by Loes Bogers (2020) https://class.textile-academy.org/2020/loes.bogers/files/recipes/biorubber/
- The Bioplastics Cookbook: A Catalogue of Bioplastics Recipes by Margaret Dunne for Fabtextiles (2018) https://issuu.com/nat_arc/docs/bioplastic_cook_book_3

MILK COMPOSITE

MAMMAL MILK CONTAINS A PROTEIN CALLED ***CASEIN***

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.

SEE ALSO: Better together: combining polymers | Gelatine bioplastic | Waste walk | Morphology of ingredients.

BIO-BASED MATERIALS

MILK COMPOSITE

INGREDIENTS	TOOLS
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	Face mask, scale, bowls, grater, oven, cooker, pots, blender

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

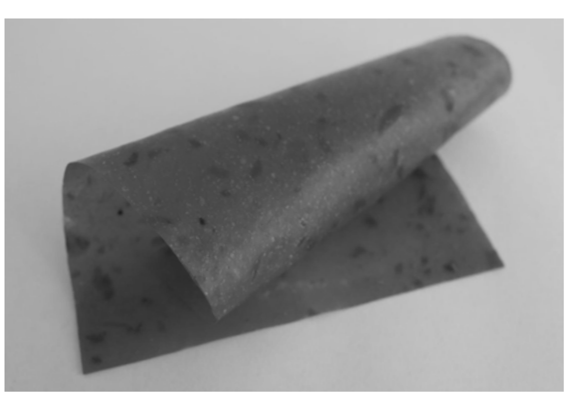
Making the composite
- Wear a mask to protect airways from small particles
- Grate the dried casein plastic into a fine powder
- Dissolve the calcium hydroxide in hot water
- Dissolve the calcium carbonate in the vinegar
- Mix both with the calcium carbonate

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.

REFERENCE
- William Christmas (1924) Casein Plastic Composite patent https://bit.ly/3C7rdYF
- Tessa Silva (2016) Chalk & Cheese, and Protein project: https://www.tessasilva.com/chalk-cheese

FRUIT LEATHER

MOST FRUITS CONTAIN THE BIOPOLYMER ***PECTIN***, A POLYSACCHARIDE



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.

SEE ALSO: Waste walk | Morphology of ingredients | Starch bioplastic | Better together: combining polymers

BIO-BASED MATERIALS

FRUIT LEATHER

INGREDIENTS	TOOLS
1 overripe mango with skin, 10 g potato starch, 8 g vinegar	Blender, walled mould, cooker, pan, spoon, scale, oven

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

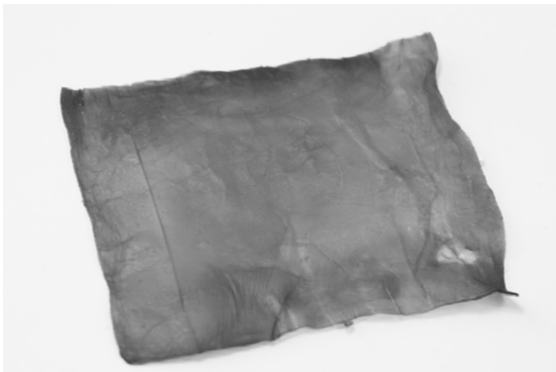
Cook the mixture
- Dissolve the starch in a dash of cold water
- Add to the hot mango mixture and stir
- Cast the paste into the mould

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

REFERENCE
- Beatriz Sandini (2018) Ephemeral Fashion Lab: https://class.textile-academy.org/2020/beatriz.sandini/projects/final-project/
- Fruit Leather, Rotterdam: https://fruitleather.nl/

MICROBIAL LEATHER

ACETOBACTER XYLINUM, A BACTERIA IN KOMBUCHA PRODUCES ***NANOCELLULOSE***



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.

SEE ALSO: DIY pH paper | Better together: combining polymers | Morphology of ingredients | Microorganisms to get to know

BIO-BASED MATERIALS

MICROBIAL LEATHER

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

TASKS

Prepare the sugary tea
- Clean and disinfect your work area and wash all tools with very hot water and soap. Rinse well and airdry (no towels!)
- Brew 400 ml of tea, add the sugar and stir to dissolve
- Allow to cool to 30 degrees Celcius
- Strain the tea and catch the liquid in the clean glass jar

Add the living culture
- Add contents of the starter pack, add white vinegar until pH of the liquid reaches pH 5-6
- Cover the jar with a coffee filter or piece of clean t-shirt, and wrap a rubber band around it to keep bugs out.
- Put in a warm spot away from sunlight

Incubate
- 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)

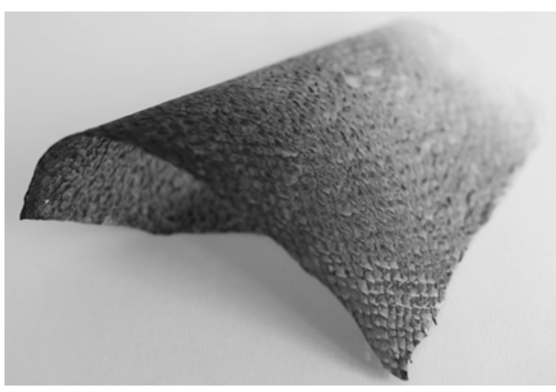
Continuous culturing
- Repeat the process by adding more cold sugary tea to the liquid SCOBY in the jar and wait another few weeks. Your culture will get stronger and grow faster over time.

REFERENCE

- Suzanne Lee (2011) Grow Your Own Clothes TedTalk: https://www.ted.com/talks/suzanne_lee_grow_your_own_clothes
- 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

FISH LEATHER

FISH SKIN IS RICH IN THE PROTEIN ***COLLAGEN***, A BIOPOLYMER



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.

SEE ALSO: Shit, hair, d(isg)ust | Waste walk | Fruit leather

BIO-BASED MATERIALS

FISH LEATHER

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

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

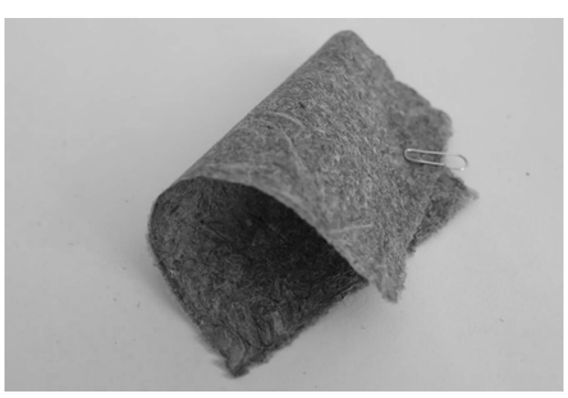
Tanning process
- Keep the skins in the jar for 3 days, shake daily for 1 min
- Take out the skins, massage and stretch them for 1 hr
- Nail them to the wooden board and leave outside to dry

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/
- Nienke Hoogvliet (n.d.) Re-Sea Me https://www.nienkehoogvliet.nl/portfolio/re-seame/

FLOWER PAPER

MOST PLANTS CONTAIN ***CELLULOSE***, A BIOPOLYMER



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.

SEE ALSO: Morphology of ingredients | Fruit leather Better together: combining polymers

BIO-BASED MATERIALS

FLOWER PAPER

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

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

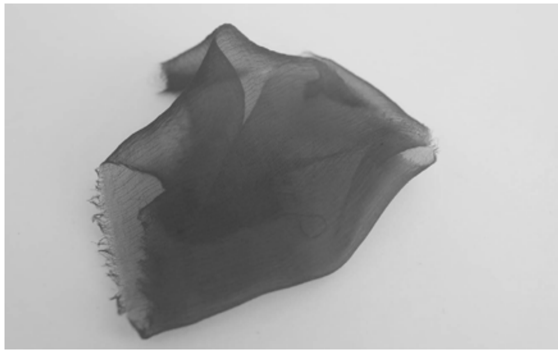
Allow to dry
- Leave to dry for about 2 days
- Carefully peel the paper off the mesh

REFERENCE

- May Babcock for Paper Slurry (2014) Hand-papermaking With Plants: https://www.paperslurry.com/2014/08/20/hand-papermaking-with-plants-illustrated-infographic/
- https://class.textile-academy.org/2020/loes.bogers/files/recipes/flowerpaper

MADDER PIGMENT EXTRACTION

LIKE INDIGO (BLUE) AND WELD (YELLOW), MADDER IS A ***GRAND TEINT***: A CLASSIC DYEPLANT THAT IS COLOUR- AND LIGHTFAST.



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.

SEE ALSO: Scouring and mordanting wool fibres | Scouring and mordanting cellulose fibres | DIY pH paper | Onion skin pigment extraction

BIO-BASED MATERIALS

MADDER PIGMENT EXTRACTION

INGREDIENTS	TOOLS
50 g dried madder roots, water	Pot, thermometer, cooker, spoon, old pantyhose, blender

TASKS

Soak the roots
- Soak the dried madder roots in water overnight
- Blend them with a blender

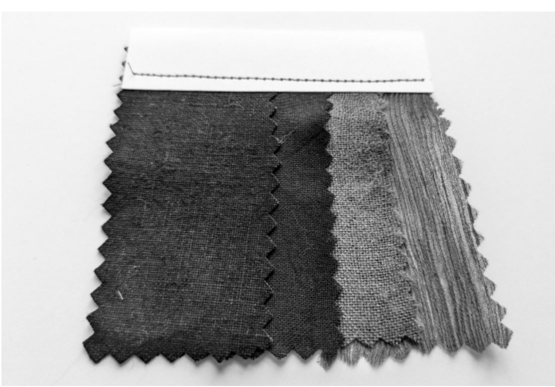
Extract the pigment
- Put the roots in the pantyhose and make a knot to close
- Put the madder in a pot and cover with water
- Optional: adding a tbsp of soda ash and/or calcium carbonate brings out the red tones
- Bring up to 60 degrees C, and keep there for 2 hours
- Overheating causes pigment to shift 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.

REFERENCE
- Joy Boutrup & Catherine Ellis (2019) The Art & Science of Natural Dyes: Principles, Experiments.

OAK GALL TANNIN EXTRACTION

OAK GALL EXTRACTION TO MAKE TANNIN MORDANT OR IRON GALL INK.



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.

SEE ALSO: DIY iron acetate

BIO-BASED MATERIALS

OAK GALL TANNIN EXTRACTION

INGREDIENTS	TOOLS
100 g oak galls, water, DIY iron acetate	Plastic bag, hammer, cooker, pot,

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

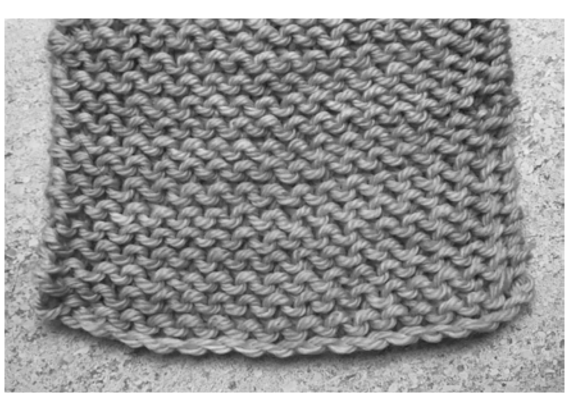
Modifying the color
- When tannins are exposed to iron ions (such as DIY iron acetate) the pale yellow/beige color will turn dark gray/purple.

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.

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/

FUNGAL DYE

SULPHUR TUFT MUSHROOM OR ***HYPHOLOMA FASCICULARE*** CAN BE USED AS WOOL DYE.



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.
Note: toxic!

SEE ALSO: DIY Iron Acetate

BIO-BASED MATERIALS

FUNGAL DYE

INGREDIENTS	TOOLS
250 g fresh sulphur tuft mushrooms, 25 g mordanted wool, DIY iron acetate	Large pot (non-food only), cooker, wash bag, spoon

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 hour
- Allow to cool, then add the wet mordanted wool
- Dye the wool at 80 degrees C for 30-60 minutes

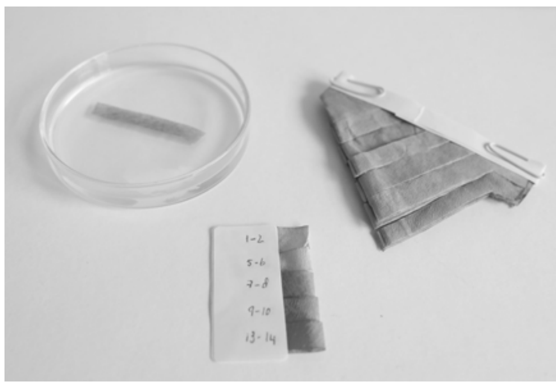
Rinsing and modifying
- Take half the wool out, rinse with warm water
- Add a splash of DIY iron acetate to the dye bath and modify the color of the remaining wool.
- Take out the wool, rinse with warm water

Note: this dye glows under a blacklight!

REFERENCE
- Miriam Rice (1974) Mushrooms for Color
- That Which Sustains Us: Lessons from the Forest Natural Dyeing with Mushrooms (2020) Museum of Vancouver: https://youtu.be/o-IXeTI7AwY

DIY PH PAPER

EXTRACT OF RED CABBAGE CHANGES COLOUR WHEN EXPOSED TO SOLUTION OF VARYING pH



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.

SEE ALSO: Microbial leather | Madder pigment extraction | Chitosan bioplastic

BIO-BASED MATERIALS

DIY PH PAPER

INGREDIENTS	TOOLS
Half a red cabbage, water, citric acid, soda ash	Food grater, pot, cooker, a clean spray bottle, filter paper or white coffee filters, 4 bowls

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

REFERENCE
- Anne Marie Helmenstine (2020) Make Red Cabbage pH paper: htt ps://www.thoughtco.com/make-red-cabbage-ph-paper-605993
- https://class.textile-academy.org/2020/loes.bogers/files/recipes/phmodifiers

DIY IRON ACETATE

DIY IRON ACETATE (ALSO ***IRON VINEGAR*** OR ***IRON LIQUOR***) IS MADE BY LETTING VINEGAR CORRODE IRON SCRAPS.

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.

SEE ALSO: Oak gall tannin extraction | Fungal dye

BIO-BASED MATERIALS

DIY IRON ACETATE

INGREDIENTS	TOOLS
White vinegar, rusty iron nails or a fine steel wool sponge	Large glass jar, household gloves

TASKS

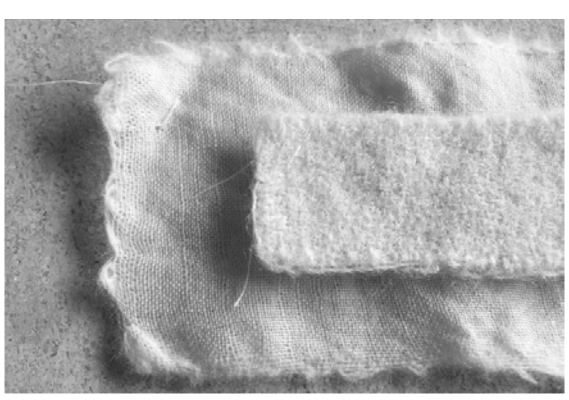
Make the iron acetate
- Put the rusty iron nails or the steel wool in the jar
- Cover with vinegar
- Leave for 1-3 weeks

Use the iron acetate
- 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.

REFERENCE
- Make Wood Stain (n.d.) https://www.apieceofrainbow.com/make-wood-stain/

SCOURING AND MORDANTING WOOL FIBRES

SCOURING AND MORDANTING WOOL (PROTEIN FIBRE) TO PREPARE IT FOR TEXTILE DYEING WITH NATURAL DYES.



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.

SEE ALSO: Scouring and mordanting silk fibres | Scouring and mordanting cellulose

BIO-BASED MATERIALS

SCOURING AND MORDANTING WOOL FIBRES

INGREDIENTS	TOOLS
100 g wool (dry weight), 1 g mild detergent, 15 g alum, 5 g cream of tartar, water	Large pot, cooker, glass jar, scale, spoon, bucket, thermometer

TASKS

Scouring
- Soak the fibres in water overnight
- Dissolve the detergent in hot water
- Put the wool in a large pot, add the solution
- 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

REFERENCE
- How to Scour (n.d.) Botanical Colors: https://botanicalcolors.com/how-to-scour/
- Joy Boutrup Catherine Ellis (2018) The Art & Science of Natural Dyes: p. 120-121.

SCOURING AND MORDANTING SILK FIBRES

SCOURING AND MORDANTING SILK (PROTEIN FIBRE) TO PREPARE IT FOR TEXTILE DYEING WITH NATURAL DYES.

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.

SEE ALSO: Scouring and mordanting wool fibres | Scouring and mordanting cellulose

BIO-BASED MATERIALS

SCOURING AND MORDANTING SILK FIBRES

INGREDIENTS
100 g silk (dry weight), 1 g sodium carbonate (soda ash), 1 g neutral detergent, 15 g alum, water, vinegar

TOOLS
Large pot, cooker, glass jar, scale, spoon, bucket, thermometer

TASKS

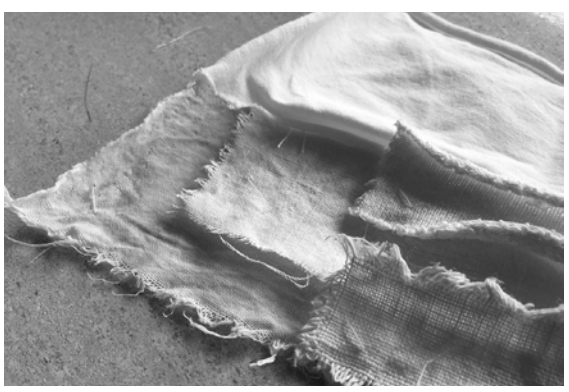
Scouring
- Soak the silk in water overnight
- Dissolve the detergent in hot water
- Put the wool in a large pot, add the solution
- Cover with water until the silk can float freely
- Bring up to 80 degrees C and keep there for 30 mins
- Allow to cool a little and rinse with warm water
- Add vinegar to 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% to re-use

REFERENCE
- How to Scour (n.d.) Botanical Colors: https://botanicalcolors.com/how-to-scour/
- Joy Boutrup Catherine Ellis (2018) The Art & Science of Natural Dyes: p. 124.

SCOURING AND MORDANTING CELLULOSE FIBRES

SCOURING, MORDANTING AND DYEING CELLULOSE FIBRES (LINEN, COTTON, HEMP, RAMIE)



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.

SEE ALSO: Scouring and mordanting wool fibres | Scouring and mordanting silk fibres

BIO-BASED MATERIALS

SCOURING AND MORDANTING CELLULOSE FIBRES

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

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

REFERENCE
- How to Scour (n.d.) Botanical Colors: https://botanicalcolors.com/how-to-scour/
- Joy Boutrup Catherine Ellis (2018) The Art & Science of Natural Dyes: p. 117, 127, 132.

MORPHOLOGY OF INGREDIENTS

UNDERSTANDING THE FUNCTIONS AND ALTERNATIVES FOR DIFFERENT COMPONENTS

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?

SEE ALSO: Better together | Material-objects | What is a material property

BIO-BASED MATERIALS

MORPHOLOGY OF INGREDIENTS

WHY
Many biomaterials recipes 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.

TASKS

Make a hypothesis
- Select a biomaterial recipe
- Research what kind of compound each ingredient is
- Use the morphological chart in this toolkit 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

REFERENCE
- Morphological Chart (2021) Loes Bogers, Cecilia Raspanti & Sam Edens (included in this toolkit)

BETTER TOGETHER: COMBINING POLYMERS

COMBINING BIOPOLYMERS TO DISCOVER OTHER MATERIAL PROPERTIES

Many bioplastics and biomaterials recipes will provide the protocol to make a material with a single biopolymer (and a plasticiser). Combining them leads to wildly different results in terms of processability and properties.

SEE ALSO: Material-objects | Morphology of ingredients | What is a material property?

BIO-BASED MATERIALS

BETTER TOGETHER: COMBINING POLYMERS

TASKS

Choose a biopolymer or biomaterial that interests you. Then make a simple recipe with it using various proportions and study it's properties and challenges.

Scientific leads

- Look into scientific publications where researchers have tried to improve or modify properties of that biomaterial (e.g. chitosan and gelatine or alginate).
- Look up any terms you don't understand, try to get an understanding of the science.
- Which ingredients do they add or remove? Why?
- Do they make changes in the protocol? Why?
- Translate these insights into recipes and try them out in various ratios.

Material designers' leads

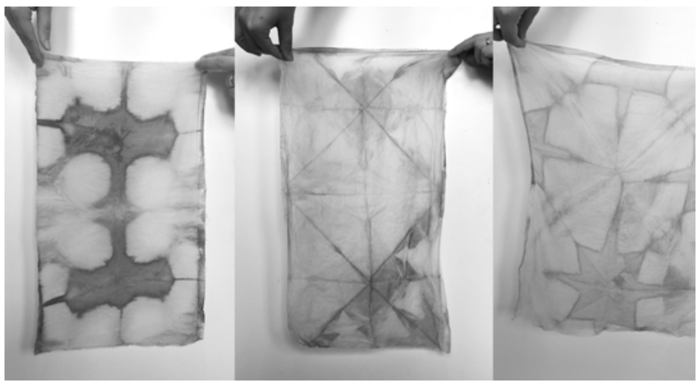
- Material designers take a very different approach, and may try out various different things they find in their direct surroundings.
- Look into ways other material designers have worked with your biopolymer of choice.
- What kind of additions do they make? Research those additions and try to understand why they lead to such different materials. Hypothesise about the functions of each of these additions?

REFERENCE

- Chemarts Cookbook (2020) Aalto University. Pdf download available for free at: https://shop.aalto.fi/p/1193-the-chemarts-cookbook/
- Materiom (2018-ongoing) https://materiom.org/
- Material Archive at AUAS (2019-ongoing) https://samplemanagementtool.org/
- Bioplastics Cookbook (2018) Fabtextiles at IAAC: https://issuu.com/nat_arc/docs/bioplastic_cook_book_3
- Recipes for Material Activism (2014) Miriam Ribul: https://issuu.com/miriamribul/docs/miriam_ribul_recipes_for_material_a

BEYOND BIOMIMICRY

MORE-THAN-HUMAN COLLABORATIONS



HUMAN-CENTRED DESIGN METHODS LED US INTO THE ANTHROPOCENE. WE NEED TO DEVELOP APPROACHES THAT ARE MORE IN TUNE WITH BIOLOGICAL SYSTEMS.

SEE ALSO: Biodata processing | A history of design and nature | DIY applied mycology

CRITICAL MAKING

BEYOND BIOMIMICRY

WHY
Collaborating 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?

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.

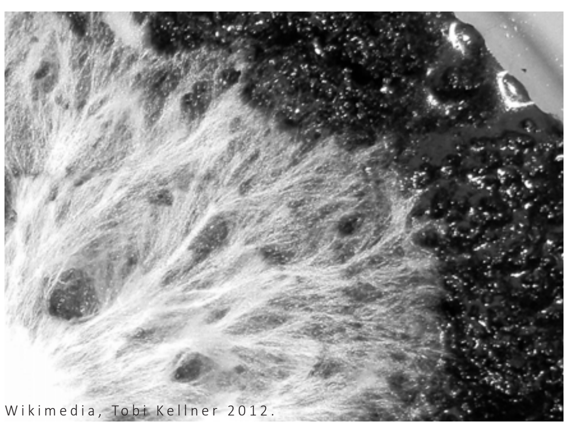
REFERENCE
- Bill Myers (2012) "Beyond Biomimicry" in: Biodesign: Na ture, Science, Creativity: p. 10-17.

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. Texti le-dyeing with bacteria. https://bioshades.bio/

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?

CROSS-DISCIPLINARY READING

PERSPECTIVES ON THE KINGDOM OF FUNGI



Wikimedia, Tobi Kellner 2012.

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?

SEE ALSO: DIY applied mycology | Microorganisms to get to know | A history of design and nature

CRITICAL MAKING

CROSS-DISCIPLINARY READING

WHY
Get an understanding of the different lenses different disciplines take, and what each of them allows us to see.

WHEN
When you are about to embark on a journey at the intersection of disciplines.

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 …..***

REFERENCES
- 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.

(UN)MAKING THE MOLD

MAKING PRODUCTS STRANGE BY LETTING THE MATERIAL SPEAK BACK

BioElectric by Jeongwon Ju (2013)

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.

SEE ALSO: Be a 3D printer | Mono-material connections | Moulding and casting | Designed to disappear

CRITICAL MAKING

(UN)MAKING THE MOLD

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

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)

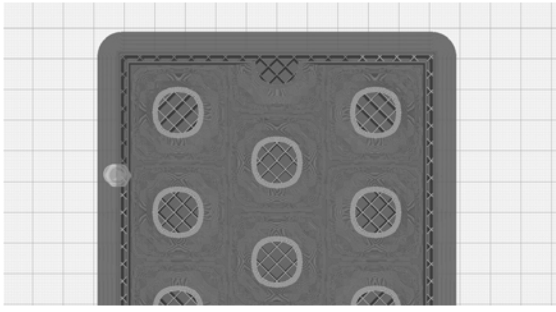
Testing and refining
- Set new goals and iterate on your mold and method
- Document the process and results, share with class

REFERENCE
- Jeongwon Ji (2013) BioElectric https://www.dezeen.com/ 2013/07/01/bioelectric-plastic-made-of-crab-shells-by-jeongwon-ji/
- Basics Mold Making (n.d.) Smooth-on https://www.smooth-on.com/howto/basics-mold-making/
- How to Make Molds (n.d) Instructables: https://www.instructables.com/How-to-make-molds

NEXT
Draw your mold design in a CAD program (e.g. Rhino). Fabricate your design and cast models in different materials.

BEING A 3D PRINTER

EXECUTE YOUR OWN GCODE TO DEFAMILIARISE YOUR MAKING PROCESS



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.

SEE ALSO: Mono-material connections | (Un)making the mould | Additive manufacturing

CRITICAL MAKING

BEING A 3D PRINTER

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.

TASKS

Prepare by reading Devendorf & Ryokai's article. Next, 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

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

OUTPUT
Users negotiate control between themselves, the system, and their materials in order to enter into meditative, reflective, and collaborative modes of making.

DEMYSTIFYING BIOTECHNOLOGY

HISTORIES AND ETHICS OF "USING LIFE"

Amino.bio

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.

SEE ALSO: Glossary of Bio-everything | Developing a bio-art or biodesign project | A history of design and nature

CRITICAL MAKING

DEMYSTIFYING BIOTECHNOLOGY

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!

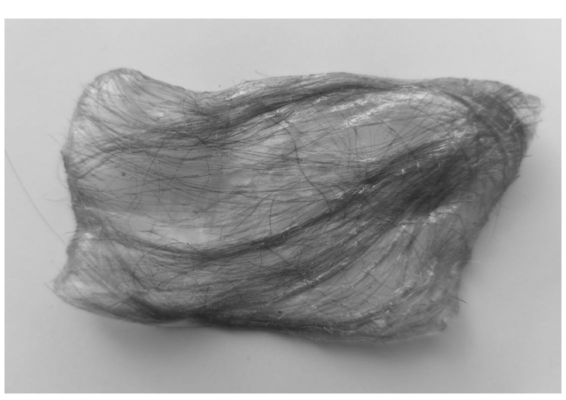
(Do-Not)-Do-It-Yourself?
- Watch this video about biohacking: https://youtu.be/fV-Edkh1iqE
- Explore these two kits: https://amino.bio/collections/genetic-engineer-101 and https://www.the-odin.com/gene-engineering-kits/
- Some argue that biotechnology should be democratised, others mostly see dangers. 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.

REFERENCE
- DIY Biohacking: Do(n't) Try This At Home (2020) Freethink: https://youtu.be/fV-Edkh1iqE

SHIT, HAIR, D(ISG)UST

TABOOS AROUND THINGS WE CONSIDER TO BE OUT OF PLACE



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).

SEE ALSO: Waste walk | A history of design and nature

CRITICAL MAKING

SHIT, HAIR, D(ISG)UST

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 realise that making materials out of food grade ingredients might be unnecessary and unsustainable, and want to start looking elsewhere.

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.

REFERENCE
- 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.

BIODATA PROCESSING

GIVE A VOICE TO LIVING ORGANISMS

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.

SEE ALSO: A history of design and nature | Beyond biomimicry

CRITICAL MAKING

BIODATA PROCESSING

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?

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.

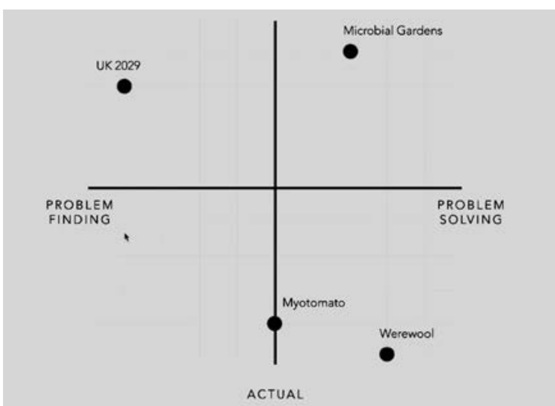
Visualize and sonify
Open the file “finalcodecoursera” in Processing. Follow the instructions in the comments. Tinker with the code and create your own visualization/sonification of the plant data. What do you imagine plants communicate about? What could be ways to express that in the visualization/sonification?

REFERENCE
- Assignment and materials by Danilo Vaz: https://github.com/dnllvrvz/BioData-Exploration

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.

DEVELOPING A BIO ART OR BIODESIGN PROJECT

TIPS AND TRICKS TO FRAME YOUR PROJECT



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?

SEE ALSO: Morphology of ingredients | Waste walk | Demystifying biotechnology | Beyond biomimicry

CRITICAL MAKING

DEVELOPING A BIO ART OR BIODESIGN PROJECT

WHEN
As you develop a project in the field of bio art or biodesign.

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 or 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.

REFERENCE
- Adaptation from: “Questions to Consider as you Develop your BDC Project”, Biodesign Challenge. https://www.biodesignchallenge.org/

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.

GLOSSARY OF ‘BIO-EVERYTHING’

DISAMBIGUATE AND CRAFT A SHARED VOCABULARY

Creating a shared vocabulary helps you understand the field and the terms used to describe it so you can position your own work.

SEE ALSO: Beyond biomimicry | Cross-disciplinary reading Demystifying biotechnology

CRITICAL MAKING

GLOSSARY BIO-’EVERYTHING’

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.

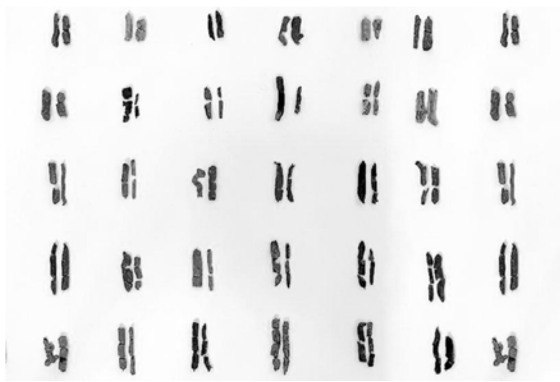
Put away your phones and laptops and discuss the keywords based on the examples and formulate your own definitions of what they each mean, based on the mindmaps you made (no internet allowed).

- 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.

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/

A HISTORY OF DESIGN & NATURE

IDEAS ABOUT NATURE ARE NOT “NATURAL”



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.

SEE ALSO: Beyond biomimicry |Developing a bio art or biodesign project | Cross-disciplinary reading

CRITICAL MAKING

A HISTORY OF DESIGN & NATURE

WHY
Understanding this old search provides designers, artists, academics with a number of frameworks and spaces to *rehearse*, *critique* and *learn* as well as position their own work.

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.

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.

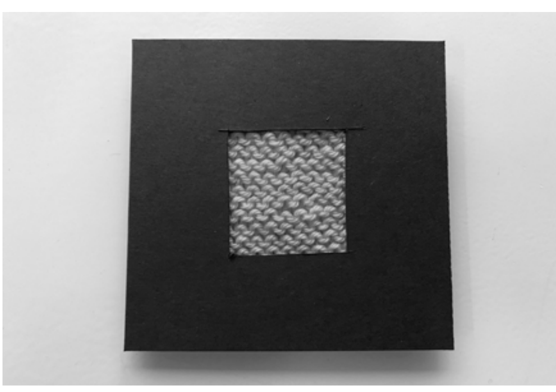
Mechanistic view of ecology:
Ecological design as mastery
Keywords: ***human-centric (solving human problems), mastery, rationality, economic growth, emotional and intellectual distance, perfection, nature as passive/controlled/mute, colonialism***

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***

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.
- Paola Antonelli & Ala Tannir (2019) Broken Nature: Design Takes on Human Survival. Catalog of the XXII Triennale Exhibition Milan.

DESIGNED TO DISAPPEAR

THE POSSIBILITY OF EPHEMERAL COLOUR AS STRENGTH



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?

SEE ALSO: What is a material property? | Morphology of ingredients

CRITICAL MAKING

DESIGNED TO DISAPPEAR

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.
- Do a light test: 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.

REFERENCE
- Levende Kleuren (2013-2015) Report of SIA Raak research project. Avans Hogeschool. https://www.avans.nl/onderzoek/projecten/detail/levende-kleuren
- 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

NEXT
Expand the idea of ephemerality beyond colour, and go through the same process for a different kind of “unstable” material.

WASTE WALK

IDENTIFY DISCARDED SOURCES OF BIOMASS THAT CAN BE TURNED INTO MATERIALS.

Going on a waste walk helps you explore untapped local waste streams and helps to unlearn our habit of working with virgin materials.

SEE ALSO: Shit, hair, d(isg)ust | A history of design and nature

CRITICAL MAKING

WASTE WALK

WHY
Learn to identify discarded sources of bio-materials that can be turned into materials of value for artmaking and design.

OUTPUT
A catalogue of potential local waste streams and their uses.

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 (e.g. 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)

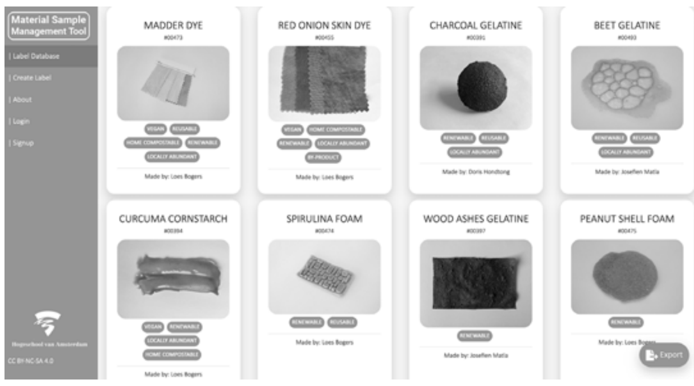
Make a catalogue of all the potentially useful waste streams you identified, and research historical crafts techniques that make use of them. Think of: basket weaving branches, paper-making, fish leather tanning or combining materials into composites. Use the references below for inspiration.

Optional: try out some of the techniques you found.

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.

INSTALL A SAMPLE MANAGEMENT TOOL

MANAGE YOUR MATERIAL SAMPLES ON- AND OFFLINE



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.

SEE ALSO: Collaborative open-source archiving | Define your eco-compatibility principles

MATERIOLOGY

INSTALL A SAMPLE MANAGEMENT TOOL

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.

This tool was 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.

TASKS

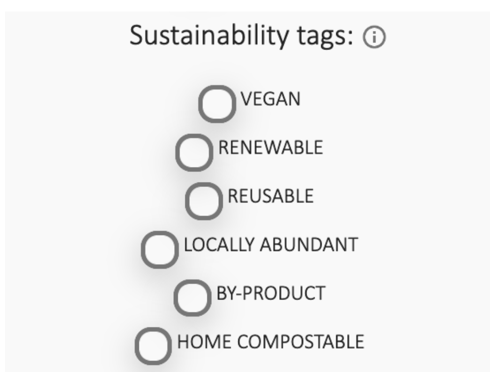
- Contact your systems administrator (or find one)
- Ask them if they are able to install the software below on your server
- Decide who you want to make admins
- Update the logo to your organisation's logo
- Add users and explore together how the tool works
- Negotiate and change things that are unclear or not useful to you
- Read the about page for more info: https://samplemanagementtool.org/#/about
- Start archiving your material samples!

REFERENCE
- https://github.com/Koziad/visualm-5
- Example of tool in use: https://samplemanagementtool.org

This tool was developed based on the OS Material Archive, a project developed at Textile Lab Amsterdam by Cecilia Raspanti and others: https://tcbl.eu/project/os-material-archive

DEFINE YOUR ECO-COMPATIBILITY PRINCIPLES

WAYS OF DEFINING "SUSTAINABILITY"



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.

SEE ALSO: Collaborative open-source archiving | Install a sample management tool

MATERIOLOGY

DEFINE YOUR ECO-COMPATIBILITY PRINCIPLES

WHY
If a product is to be truly eco-compatible during its life cycle it must minimise, if not eliminate, resource con-sumption (energy and materials) and emissions (air, water, and solid waste). Lerma, diGiorgi & Allione developed a multi-criteria interpretation system to 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).

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 (consider homo geneity of material, and quality of recycled output)
- Biodegradability (time and conditions required to decompose)

Ethical production:
- Is the feedstock or semi-finished product or ingredient manufactured in a responsible way?

REFERENCE
- Beatrice Lerma, Claudia diGiorgi & Cristina Allione (2013) Design & Materials: Sensory perception sustainability project: p. 103: https://bit.ly/3BHM9nZ

NEXT
Select and - if necessary - simplify some of the parameters to use them as guide- lines in your projects.

COLLABORATIVE OPEN-SOURCE ARCHIVING

SHARE YOUR FINDINGS, BUILD ON EACH OTHER'S WORK

Labels designed by Maria Viftrup for Textile Lab Amsterdam can be downloaded here: https://bit.ly/3wdJkdb

DOCUMENTING, ARCHIVING, AND PRESENTING YOUR MATERIAL EXPLORATIONS TOGETHER OPENS UP ACCESS TO A WEALTH OF OPTIONS YOU COULD NEVER EXPLORE ALONE.

SEE ALSO: Define your eco-compatibility principles | Install a sample management tool

MATERIOLOGY

COLLABORATIVE OPEN-SOURCE ARCHIVING

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.

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
- 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")

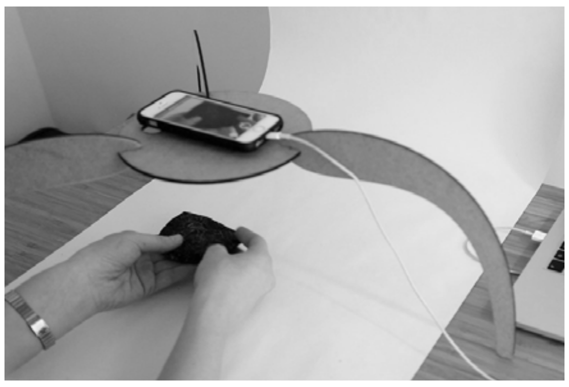
Display
- Trim your materials if needed, and mount them onto the labels
- Attach a hang tab or other system to hang them up
- Put them in your material archive.

REFERENCE
- OS Material Archive developed at Textile Lab Amsterdam (2016-ongoing): https://tcbl.eu/project/os-material-archive

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/

TACTILITY VIDEO

EXPLORE AND DOCUMENT THE SENSORY QUALITIES OF A MATERIAL THROUGH VIDEO



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.

SEE ALSO: What is a materials experience | What is a material property

MATERIOLOGY

TACTILITY VIDEO

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?***

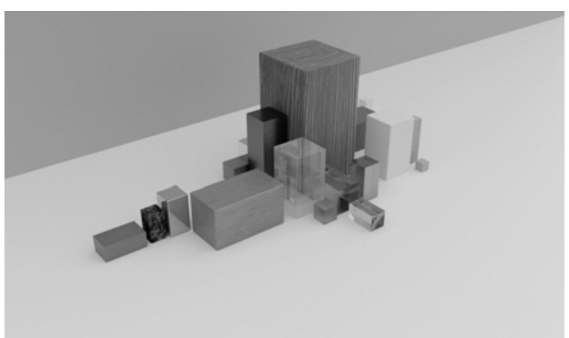
TASKS

- 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

REFERENCE:
- Loes Bogers (2020) Tutorial for a tactility video: https://class.textile-academy.org/2020/loes.bogers/projects/outcomes/tools_and_templates/tactilityvideo/

MATERIAL-OBJECTS

EXPLORING FORM, FUNCTION AND MATERIALITY



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.

SEE ALSO: What is a material property? | Morphology of ingredients | Better together | Designed to dissapear

MATERIOLOGY

MATERIAL OBJECTS

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 materialty by letting the material itself represents the science behind materials in the context of a material library. 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.

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

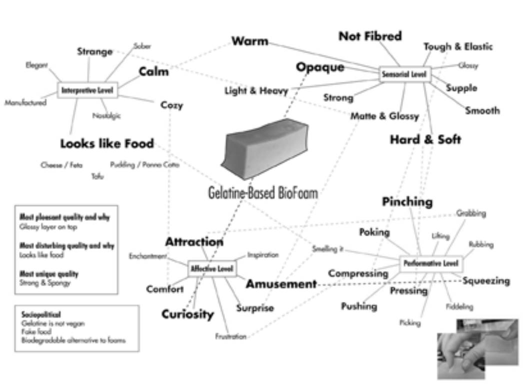
Make
- Create a series of objects that have the same form, but are made with a different material recipe.
- Variations between the recipes can be very small and incremental (e.g. from no glycerine to a lot of glycerine), or substantial (e.g. using to entirely different recipes with different biopolymers).
- 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.

REFERENCE
- Zoe Laughlin (2010) How can the Science of Materials be Repre sented by the Materials Themselves in a Materials Library? https://doi.org/10.13140/RG.2.2.16034.94405

WHAT IS A MATERIALS EXPERIENCE?

MATERIALS AS BEING SIMULTANEOUSLY TECHNICAL AND EXPERIENTIAL



The notion of ***materials experience*** emphasises 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.

SEE ALSO: What is a material property? | Tactility video

MATERIOLOGY

WHAT IS A MATERIALS EXPERIENCE?

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.

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.

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

WHAT IS A MATERIAL PROPERTY?

DEVELOP A SHARED VOCABULARY UNDERPINNED BY EXAMPLE MATERIALS AND TACTILE EXPERIENCES

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.

SEE ALSO: What is a materials experience? | Tactility video | Material-objects

MATERIOLOGY

WHAT IS A MATERIAL PROPERTY?

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

Visualise 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.

REFERENCE

- Properties of Materials Introduction (2018) Science Learning Hub https://www.sciencelearn.org.nz/resources/2659-properties-of-materials-introduction
- 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

RECYCLING

INDUSTRIAL PROCESSING AND CONVERSION TECHNIQUES

John Lambert Pearson (n.d.)

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 explorepossibilities of biomaterials in depth.

SEE ALSO: Extractive Manufacturing | Additive Manufacturing | Moulding & Casting | Transforming Assembling | Finishing

MATERIOLOGY

RECYCLING

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.

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.

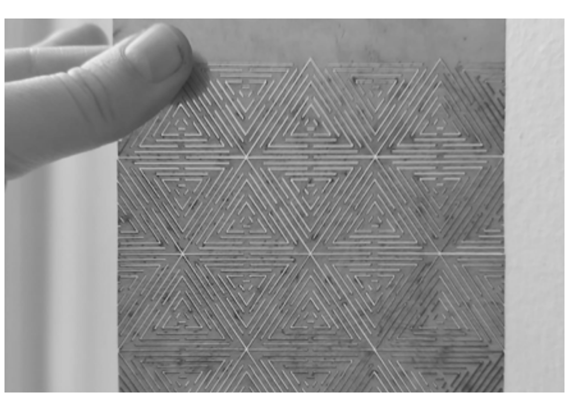
- ***Chemical recycling*** (treatment to separate constituents for reuse)
- ***Mechanical recycling*** (shredding, beating, grinding, crushing)
- ***Organic recycling*** (composting to produce fuel or fertilisers)

REFERENCE

- Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry's Guide to Materials and Technologies.

EXTRACTIVE MANUFACTURING

INDUSTRIAL PROCESSING AND CONVERSION TECHNIQUES



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MATERIOLOGY

EXTRACTIVE MANUFACTURING

WHY

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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).

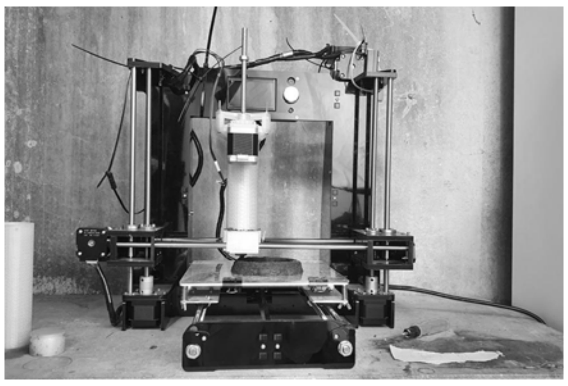
- ***Cutting*** (e.g., saws, scissors, knives, lasercutting, hotwire, piercing)
- ***Machining*** (drilling, milling, turning, abrasion)
- ***Engraving*** (laser engraving, etching, carving)

REFERENCE

- Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry's Guide to Materials and Technologies.

ADDITIVE MANUFACTURING

INDUSTRIAL PROCESSING AND CONVERSION TECHNIQUES



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SEE ALSO: Recycling | Extractive Manufacturing | Moulding & Casting | Transforming | Assembling | Finishing

MATERIOLOGY

ADDITIVE MANUFACTURING

WHY
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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.

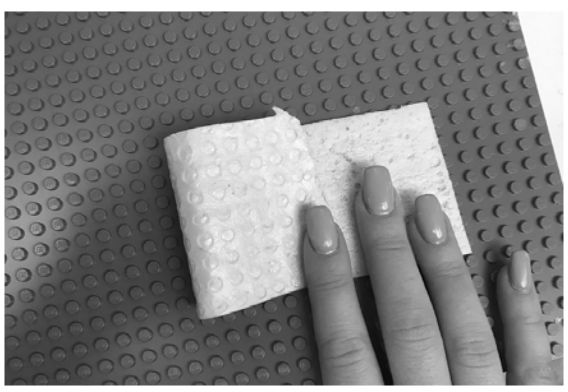
With **additive manufacturing**, you build your design by adding or fusing materials in layers on top of one another.

- ***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.

MOULDING AND CASTING

INDUSTRIAL PROCESSING AND CONVERSION TECHNIQUES



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SEE ALSO: Recycling | Additive Manufacturing | Extractive Manufacturing | Transforming | Assembling | Finishing

MATERIOLOGY

MOULDING AND CASTING

WHY
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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.

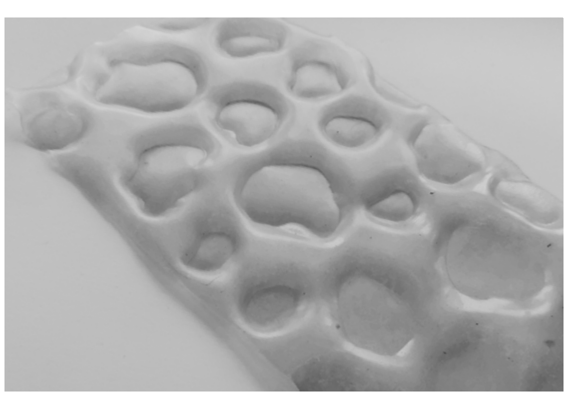
Moulding & casting are both processes in which materials in a non-defined shape or stage are directly converted into a defined shape. Casting is mostly done with metals and clay and moulding with plastics.

- ***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.

TRANSFORMING

INDUSTRIAL PROCESSING AND CONVERSION TECHNIQUES



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SEE ALSO: Recycling | Additive Manufacturing | Extractive Manufacturing | Moulding & Casting | Assembling | Finishing

MATERIOLOGY

TRANSFORMING

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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.

- ***Folding*** (cold vs hot, optional: scoring, applying stiffeners)
- ***Thermoforming*** (vacuum forming, dome blowing)
- ***Stamping*** (cold pressing sheets using moulds)

REFERENCE
• Daniel Kula & Élodie Ternaux (2008) Materiology: The Creative Industry's Guide to Materials and Technologies.

ASSEMBLING

INDUSTRIAL PROCESSING AND CONVERSION TECHNIQUES

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SEE ALSO: Recycling | Additive Manufacturing | Extractive Manufacturing | Moulding & Casting | Transforming | Finishing

MATERIOLOGY

ASSEMBLING

WHY

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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).

- ***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.

FINISHING

INDUSTRIAL PROCESSING AND CONVERSION TECHNIQUES

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 explorepossibilities of biomaterials in depth.

SEE ALSO: Recycling | Additive Manufacturing | Extractive Manufacturing | Moulding & Casting | Transforming | Assembling

MATERIOLOGY

FINISHING

WHY

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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.

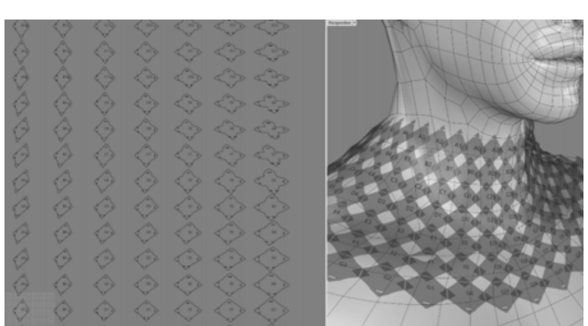
Finishing is a surface treatment, either for protection or decorative purposes. Biomaterials can also be developed as a finish for other materials.

- ***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.

MONO- MATERIAL CONNECTIONS

EXPLORE INTERLOCKING STRATEGIES TO DEVELOP MONO-MATERIAL DESIGNS



Interlocking necklace design, Lorenzo Massini (2020)

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***.

SEE ALSO: (Un)making the mould | Be a 3D printer

MATERIOLOGY

MONO-MATERIAL CONNECTIONS

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.

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.

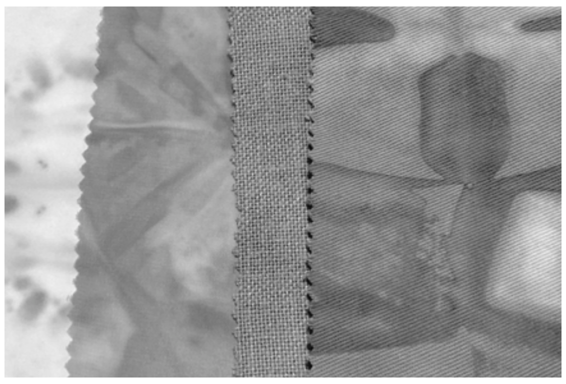
NEXT

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.

REFERENCE
- Zoe Romano (2019) Circular Open-Source Fashion, for Fabricademy. https://class.textile-academy.org/classes/2019-20/week03/ and https://oscircularfashion.com/
- Tutorial interlocking tesselation design with Rhino & Grasshopper by Lorenzo Massini (2020) https://youtu.be/Nb_lfpgM9WU

MICROBIAL DYE

GROWING PIGMENTED BACTERIA ON TEXTILES



Several microorganisms naturally produce pigments, some of which are suitable as textile dyes and inks for artmaking. Understanding their needs and lifecycle will allow you to collaborate with bacteria creatively.

SEE ALSO: Aseptic technique | Biolab rules | Setting up a community biolab | Morphology of Tools | Organisms to get to know

DIY MICROBIOLOGY

MICROBIAL DYE

TOOLS and MATERIALS
Salt, yeast extract, peptone, glycerine, 70% denatured alcohol, autoclaveable bags, glassware, rubber bands, Fiberfil synthetic wool, micropipette and tips, parafilm. Access to a biolab and plate of Janthinobacterium Lividum BSL-1 teaching strain.
Optional: glue clamps, acrylic shapes.

TASKS

Prepare the substrate
- Apply shibori/tie dye if desirable. Or apply a pattern using liquid latex (you can use a stencil for this too). Place in autoclaveable bags or large petri dishes.

Prepare a liquid medium and Fiberfil
250 g hot water | 0.75 g yeast extract | 1.25 g peptone | 1.25 g salt (NaCL) |
5 g glycerine (1-2% by weight to boost pigment production)
- Mix the ingredients. Pour onto textile until fully soaked, but without making puddles in the bag.
- Cut off some pieces of Fiberfil synthetic wool, wrap in aluminum foil.
- Autoclave everything for 20 mins (<500 ml) or 45 mins (>500 ml), don't overload the pressure cooker, allow air to circulate. Close bags with clips after opening.

Inoculate
- Allow textiles with medium to cool to 30 degrees C. Inoculate using aseptic technique. When working with a liquid inoculum: use a micropipette. When working with culture on an agar plate, use an inoculation loop.
- Note: be careful not to burn the bag with the hot loop! Ask someone to assist you with opening and closing the bag.
- Seal dishes with parafilm and/or plug bags with Fiberfill, then wrap with rubber band to close the bag. The Fiberfil acts as a gas exchange/filter.

Incubate
- Incubate at 22-26 degrees C for 3-5 days or until desired color is achieved. Make sure bags are upright so the culture cannot contaminate the filter.

Sterilization
- Put the bags/plates in the pressure cooker without opening them. Autoclave for 45 mins (creased textile is more difficult to autoclave).
- Wash thoroughly before drying the textile.

REFERENCE
• Bioshades (2019) TCBL & Textile Lab Amsterdam: https://bioshades.bio

MICROORGANISMS TO GET TO KNOW

SUPERPOWERED ORGANISMS THAT ARE SUITABLE FOR SCHOOLS

Exploring biology but don't have a science background? Get to know some friendly organisms with interesting properties to experiment with. The microorganisms on this card are beginner-friendly beings with interesting properties to explore.

SEE ALSO: Setting up a community biolab | Biosafety containment levels | Lab rules

DIY MICROBIOLOGY

MICROORGANISMS TO GET TO KNOW

NOTE
In all cases, it is important to learn to identify contamination. When in doubt: don't continue the experiment or open it: sterilize and throw it out.

TASKS

The organisms marked with an asterisk* have been identified as suitable use in secondary school labs, are fast growers that aggressively take out competitors (low contamination risk), or grow in acidic environments unwelcoming for most competitors (low contamination risk).

Gray oyster (Pleurotus Ostreatus)*
Edible wood-loving mushroom that can be trained to grow on almost anything (straw, coffee, hemp, wood, paper, cigarette buds). Competitors don't stand much chance against this aggressive fungus, so contamination rates are relatively low, making it great for beginning fungus growers. Spores can cause allergic reactions, search for a sporeless strain (e.g. Homegreen.nl)

Reishi (Ganoderma Lucidum)
Grows slower than oyster mushrooms, but its mycelium is smooth and very strong. Primary decomposer that can thrive even on fresh (not composted) wood substrates (e.g. hydrated mix of 10 parts hardwood saw dust, 2 parts wheat bran, 1 part gypsum). Is less dependent on high humidity and fresh air. Reishi dyes a warm gold beige/rust color with ammonia. Also medicinal.

REFERENCE
• Suitable and unsuitable microorganisms (2018) Microbiology in Schools Advisory Committee (MISAC): https://www.misac.org.uk/PDFs/MISAC_Suitable%20and%20Unsuitable%20Microorganisms2.pdf

MICROORGANISMS TO GET TO KNOW

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Janthinobacterium lividum*
Janthinus is Latin for violet, which is also the color of the pigment violacein this aerobic bacteria produces when it metabolizes glycerine. This pigment can be used as biodegradable dye for textiles that doesn't contain the harmful chemicals and heavy metals many synthetic dyes contain.

Slime mould*
Physarum Polycephalum is an a-cellular slime mould that feeds on bacteria and fungi spores (found in e.g. rotting wood). It has "senses" and a primitive intelligence. It can sense wheat and soy nutrients in its environment and has a very efficient way of forming networks for nutrient distribution. It can find the shortest path through a maze and exhibits some form of memory.

Acetobacter xylinum*
Is a bacteria that has the ability to synthesize cellulose from sugars in acidic environments. This biofilm has been used for papermaking, textiles, packaging, wound care and drug delivery systems. Together with other yeasts and bacteria, it is also found in the fermented tea drink Kombucha.

REFERENCE
• Suitable and unsuitable microorganisms (2018) Microbiology in Schools Advisory Committee (MISAC): https://www.misac.org.uk/PDFs/MISAC_Suitable%20and%20Unsuitable%20Microorganisms2.pdf

BIOSAFETY: CONTAINMENT LEVELS

LEVELS OF CONTAINMENT TO ENSURE SAFETY OF PEOPLE AND ENVIRONMENT

Kelsey Chisamore, The Noun Project.

CONTAINMENT IS THE TERM USED TO DESCRIBE METHODS, PRACTICES, PROCEDURES, FACILITIES, AND EQUIPMENT USED TO SAFELY MANAGE BIOHAZARDOUS MATERIALS IN THE LABORATORY.

SEE ALSO: Starting a community biolab | Lab Rules | Aseptic technique

DIY MICROBIOLOGY

BIOSAFETY LEVELS

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.

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?

REFERENCE
• Microbiology Society (2016) Basic Practical Microbiology: a Manual: https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html

HANDWASH EXPERIMENT

WHAT IS LIVING ON YOUR HANDS?

PRACTICE POURING AGAR PLATES AND DISCOVER THE GERMS GROWING ON YOUR SKIN. HAND WASHING THOROUGHLY IS PART OF GOOD MICROBIOLOGICAL PRACTICE BECAUSE IT REDUCES THE CHANGE OF GROWING UNWANTED ORGANISMS (CONTAMINATION).

SEE ALSO:Biolab rules

DIY MICROBIOLOGY

HANDWASH EXPERIMENT

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.

TASKS

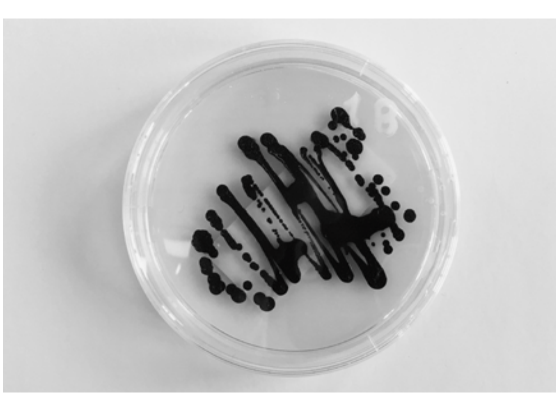
Study ***Basic Practical Microbiology: A Manual*** in preparation for class, followed by the handwashing experiment. Students practice pouring plates using aseptic technique, and learn to use the autoclave to sterilize media and materials.

- 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 35 degrees Celcius
- Pour agar into sterilized petri dishes using aseptic technique
- Take a bathroom and coffee/tea break until agar sets
- Group 1 washes hands with 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

REFERENCE
• Basic Practical Microbiology: A Manual (2016) Microbiology Society: https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html

BIOLAB RULES

THE IMPORTANCE OF GOOD MICROBIOLOGICAL LABORATORY PRACTICE (GMLP)



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 POSSIBILITY OF INFECTION.

SEE ALSO: Handwash experiment | Organisms to get to know

DIY MICROBIOLOGY

BIOLAB RULES

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 familiarise students with key concepts, tools and rules in a biolab, before starting any investigations.

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 media)
- 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 (polyester/cotton blend) 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.

REFERENCE
• Basic Practical Microbiology: A Manual (2016) Microbiology Society: https://microbiologysociety.org/publication/education-outreach-resources/basic-practical-microbiology-a-manual.html

SET UP A COMMUNITY BIOLAB

A PROPER ENVIRONMENT PREVENTS CONTAMINATION AND HEALTH HAZARDS

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.

SEE ALSO: Biosafety Containment Levels | Lab Design | Organisms to Get to Know | Biolab Rules

DIY MICROBIOLOGY

SET UP A COMMUNITY LAB

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. Familiarising 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.

TASKS

- Study the ***Community Biology Biosafety Handbook*** thoroughly with your team (see reference)
- Consult someone with experience as lab technician over seeing 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.

REFERENCE
- Angela Armendariz, Patrik D'haeseleer and others (ongoing) Community Biology Biosafety Handbook: https://bit.ly/3k9Tkz9
- Health & Safety (2018) Microbiology in Schools Advisory Committee, UK: https://www.misac.org.uk/healthandsafety.html

LAB DESIGN

RECOMMENDATIONS FOR MATERIALS, EQUIPMENT, AND INFRASTRUCTURE

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.

SEE ALSO: Setting up a community biolab | Aseptic technique | Cone of protection | Lab rules

DIY MICROBIOLOGY

LAB DESIGN

CONSIDERATIONS

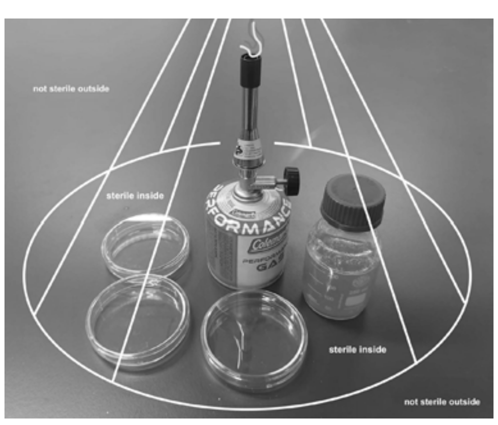
- Walls and floors should be smooth, impermeable to liquids and easy to clean. No carpets or flammable materials.
- Benchtops should be impermeable to liquids including disinfectants, and chemicals. Benchtops should be scratch-resistant and have no open seams.
- Sink for handwashing, dishwashing and 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.
- Note: don't make bioplastics inside a microbiology lab, they will get contaminated. Making bioplastics and doing creative work is done elsewhere.

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

REFERENCE
- Angela Armendariz, Patrik D'haeseleer and others (ongoing) "Lab Infrastructure & Design" in: Community Biology Biosafety Handbook: https://bit.ly/3k9Tkz9

CONE OF PROTECTION

A LOW-TECH STERILE TECHNIQUE FOR WORKING ON AN OPEN BENCH.



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.

SEE ALSO: Aseptique techniques | Lab rules

DIY MICROBIOLOGY

CONE OF PROTECTION

TOOLS

Bunsen burner, lighter, alcohol 70%

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 20-25 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
- <u>Don't wear gloves or synthetic face masks</u> (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 when it's on

REFERENCE
- "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

MORPHOLOGY OF TOOLS

FINDING ALTERNATIVES TO SPECIALIST EQUIPMENT

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.

SEE ALSO: Set up a community biolab | Lab design

DIY MICROBIOLOGY

MORPHOLOGY OF TOOLS

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.

REFERENCE
• 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

DIY APPLIED MYCOLOGY

COLLABORATING WITH FUNGHI

MYCOLOGY IS THE STUDY OF FUNGI AND THEIR APPLICATIONS IN SEVERAL INDUSTRIES (FOOD, MATERIALS, PIGMENTS, MEDICINE, BIOREMEDIATION). THE AVAIL-ABILITY OF TOOLS AND DIY PROCESSES MAKE THIS FIELD ACCESSIBLE TO ENTHUSIASTS.

SEE ALSO: Set up a community biolab | Aseptic techniques | Mycelium-hemp composite

DIY MICROBIOLOGY

DIY APPLIED MYCOLOGY

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 and allergies (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***, ***sterilise*** and ***inoculate*** a grain jar

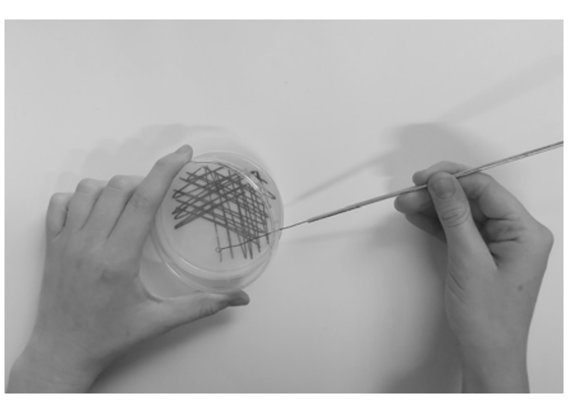
Learn how to colonize a bulk substrate to create fungal composites
- Find out which substrates your strain thrives on (what it likes to eat)
- Learn how to ***pasteurise***, ***inoculate*** and ***incubate*** bulk substrates
- Learn maintain and dry a bulk substrate

Learn how to train a strain to digest a particular food
- Train your mushroom to eat abundant waste, or train it for mycoremediation

REFERENCE
• Peter McCoy (2016) Radical Mycology
• Freshcap Mushrooms Blog and video channel https://learn.freshcap.com/growing/ and https://www.youtube.com/c/freshcapmushrooms

ASEPTIC TECHNIQUES

POURING PLATES, INOCULATING WITH LOOPS, PIPETTES AND SCALPELS



Aseptic technique is a set of procedures to prevent unwanted microorganisms from contaminating your experiments and your environment.

SEE ALSO: Cone of protection | Lab rules

DIY MICROBIOLOGY

ASEPTIC TECHNIQUES

TOOLS
Bunsen burner, alcohol, scalpel/loop/pipette, agar plates, glass bottle.

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 alum-inum 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.

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