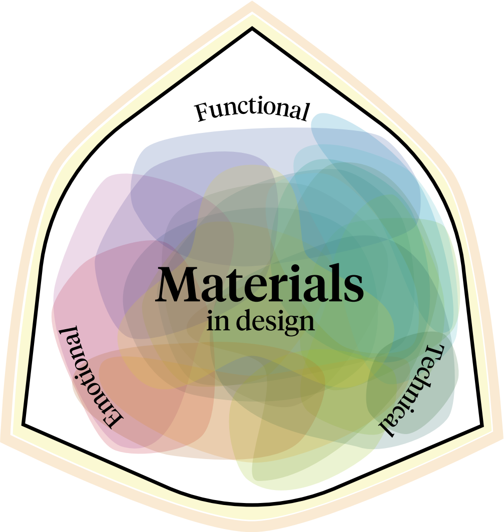
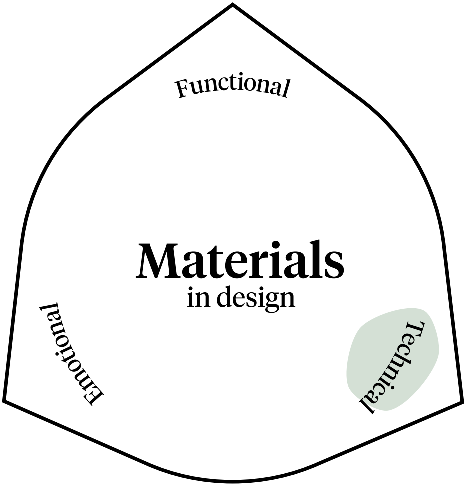
# Material Pathways

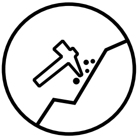
design school kolding

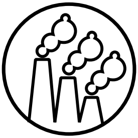



www.materialpathways.dk

# Bio-Synthetic Material





# Bio-Synthetic Material

### What?
Bio-synthetic materials can either be synthetic imitations of materials found in nature (1) or modifications of naturally occurring materials to obtain alternative properties (2). This includes plastics made entirely or partly from renewable resources such as corn starch, waste, fats etc.

### Why?
Many materials found in nature are superior to the materials we can produce synthetically (1) and by slightly altering naturally occurring materials, they can e.g. withstand different climates or give a better yield (2). This means a potential overall increase in resource efficiency, for example by reducing carbon emissions.

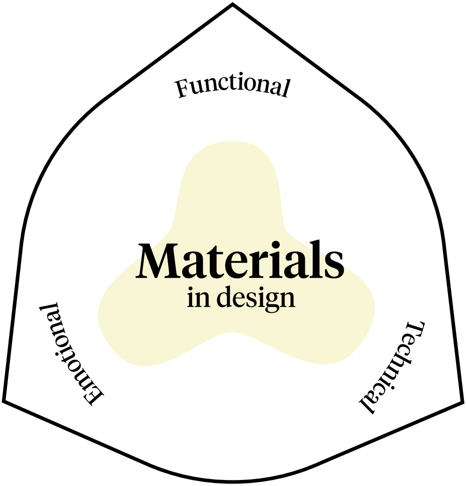
### Challenges
- Using alternative resources to produce materials may cause shortage of resources in other sectors. Production of bio-plastics use agricultural land that could otherwise be used for food production or wildlife.
- It is essential to explore possible implications of altering naturally occurring materials and making them part of the eco-system.

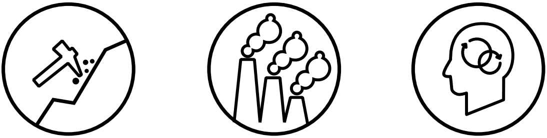
### Examples
- Genetically modified (GMO) crops such as cotton and soy that have been modified to become pesticide resistant (both) or to improve the quality of the fatty acids (soy).
- PlantBottle, used by CocaCola in some regions is a PET made out of 30% plant-based material.
- The company Bolt Threads is working on synthetically producing silk.

### This Card Links To
Living Material / Material Biomimicry / Material Origin / Material Scarcity / Material Speculation / Material Substitution / Material Tinkering

### Further Reading
Ashby (2016). Chapter 8 - Scaling Up Biopolymer Production. In: Materials and Sustainable Development. Butterworth-Heinemann, pp. 117–33 / Le Feuvre & Scrutton (2018). A living foundry for Synthetic Biological Materials: A synthetic biology roadmap to new advanced materials. Synthetic and Systems Biotechnology 3(2), pp. 105–12 / Oxman (2015). The Intersection of Technology and Biology. TED Talk.

# Living Material



# Living Material

### What?
Working with living materials means merging material and product manufacturing by benefitting from a living material or organism's innate growth behaviour. These behaviours can be further utilized through self-driven or systematized material repair, embedded in the material itself. 'Living' often refers to organisms; however here also inorganic materials that grow are considered.

### Why?
Working with living materials can build understanding of and respect for materials as living nature, optimize the use of material resources and thus build more resilient systems. Furthermore, as production will depend on the materials growing, it can strengthen slow design thinking for designers and users.

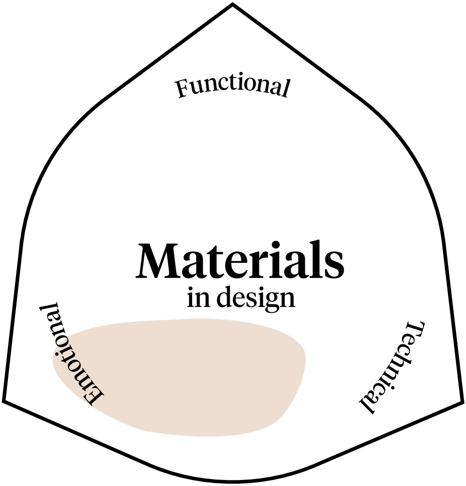
### Challenges
- Production time is dependent on the growing material
- It is necessary to fully understand the nature of the material in mind and from that design an optimal production environment.

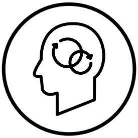
### Examples
- Diana Scherer's plant roots that are grown in moulds to obtain specific shapes and structures (www. dianascherer.nl)
- A research group at Aalborg University is developing self-healing glass that can be applied in e.g. smartphone screens and car windshields.
- Biocouture by Suzanne Lee, is a cellulosic material grown from tea, sugar and bacteria in a fermentation process.
- Full Grown is a project which explores creating 'grown' chairs and lamps from trees.

### This Card Links To
Bio-Synthetic Material / Material Ageing / Material Biomimicry / Material DIY / Material Speculation / Material Tinkering / Material Waste

### Further Reading
de Pauw, Kandachar & Karana (2015). Assessing sustainability in nature-inspired design. International Journal of Sustainable Engineering 8(1), pp. 5–13 / Ghosh (2009). Self-healing Materials: Fundamentals, Design Strategies, and Applications. Wiley.

# Material Ageing



# Material Ageing

## What?
Material ageing describes how a material reacts to its surrounding environment and use over time. Material ageing can be of both technical (e.g. fatigue) and sensorial (e.g. patina) character.

## Why?
Materials that age 'gracefully' can increase a product's emotional and functional longevity. Also, how a material age will impact relevant circular design strategies.

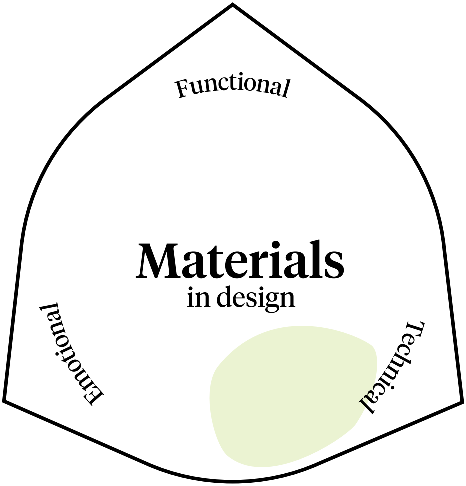
## Challenges
- The social and cultural values and meanings incorporated in the ageing of materials can be difficult to comprehend.
- Changes in certain materials (e.g. novel materials or composites) might be challenging to predict.
- It can require time to test material ageing and testing methods might be inadequate or have to be developed.
- Data on users' physical interaction with objects and their responses to materials' ageing may be limited.

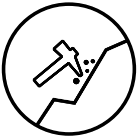
## Examples
- Hazal Ertürkan's Chronomaterials explores the way materials can evoke positive experiences through their temporal qualities.
- Copper's changing visual appearance due to surface oxidation is often used as a beautiful ageing element in architecture.
- Wabi-sabi is a Japanese philosophy that embraces the aesthetics of material and/or object imperfection and ageing.

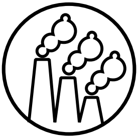
## This Card Links To
Material Degradation / Material Perception / Material Sensing

## Further Reading
Chapman (2005). Emotionally Durable Design. Taylor & Francis / Cooper (2010). Longer Lasting Products. Gower Publishing, pp. 83-85 / Lilley, Bridgens, Davies & Holstov (2019). Ageing (dis)gracefully: enabling designers to understand material change. Journal of Cleaner Production 220, pp. 417-430.

# Material Bio-Ecology





# Material Bio-Ecology

### What?
Taking into account the bio-ecology of a material means to consider it in relation to interactions between plants, animals, humans and cultures and thus the impact of materials use in a larger eco-system. On a micro-level this includes the ecological footprint of a material throughout its lifecycle; on a macro-level the implications of resource promotion globally.

### Why?
Most materials undergo heavy processing before they reach the market. Reduced environmental impact through responsible use of energy and natural resources, maintenance of biodiversity, preservation of regional ecological balances, enhancement of soil fertility and maintenance of water quality and minimising waste generation are desirable aspects.

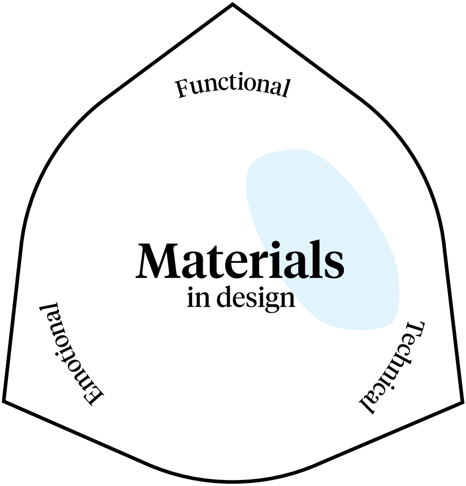
### Challenges
- Working with bio-ecologies can require specialist knowledge and/or collaborations as it may span several knowledge domains.
- Lack of transparency and/or data can be barriers for gaining insight into interactions in a larger eco-system.
- Certifications may not be compatible across systems, countries and organisations.

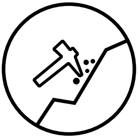
### Examples
- The Spanish company, Organic Cotton Colours applies bio-dynamic agricultural strategies including using natural colours of cotton fibres.
- The Global Organic Textile Standard (GOTS) is an international standard for organic textiles, predominantly used for cotton fibres.
- The refinement of metals from mined minerals requires large amounts of energy and generates a lot of waste.

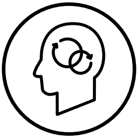
### This Card Links To
Material Geography / Material Origin / Material Substitution / Material Transparency

### Further Reading
Demos (2016). Decolonizing Nature. Contemporary Art and the Politics of Ecology. Sternberg Press / Smith et al. (2019). Organic Farming Provides Reliable Environmental Benefits but Increases Variability in Crop Yields: A Global Meta-Analysis”. Frontiers in Sustainable Food Systems vol 3, article 82.

# Material Biomimicry





# Material Biomimicry

### What?

Material biomimetics comprises of man-made material systems that emulate nature's patterns and strategies in order to optimise material properties and to develop new functionalities.

### Why?

Across billions of years, nature's own structures and processes are tested and proven to work. Material designs inspired by nature can therefore lead to more efficient and safer resource use through the replacement of chemicals with sophisticated structures. They can also lead to durable materials with minimal resources.

### Challenges

- Bio-mimicking materials are not necessarily environmentally friendly.
- Nature's systems can be difficult to fully mimic due to a high level of complexity. Thus, a high level of technology and engineering can be required.
- Cross-disciplinary collaboration may be necessary to take material explorations further.

### Examples

- The effect of the super hydrophobic surface of lotus flowers' leaves (among many other leaves) can be used to design highly water repellent and thus self-cleaning surfaces.
- The hooks on bur fruit originally inspired the development of Velcro tape.
- The development of artificial spider silk not only mimics the silk proteins, but also the spinning process of the spider glands.

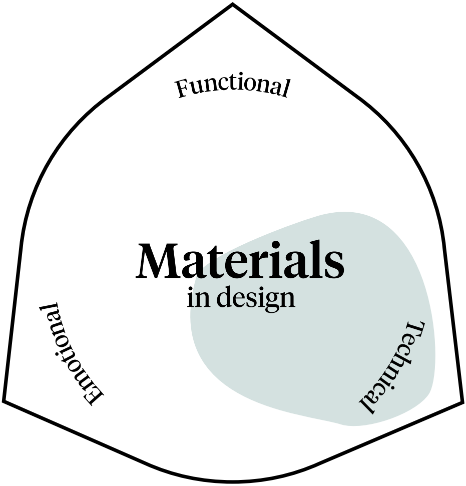
### This Card Links To

Bio-Synthetic Material / Living Material / Material Composite / Material Responsivity / Material Speculation / Material Substitution

### Further Reading

Benyus (2002). Biomimicry: Innovation Inspired by Nature. Harper Perennial / Lenau, Orrù & Linkola (2018). Biomimicry in the Nordic Countries. Nordic Council of Ministers / Ternaux (2012). Industry of Nature: Another Approach to Ecology. Frame Publishers.

# Material Circulation




# Material Circulation

### What?
Material circulation deals with different means to keep resources in a constant loop. This includes repurposing materials to develop and rework materials into new and other uses, mechanically recycling to alter materials without changing the basic chemical structure, and chemically recycling to degrade and rebuilding materials from their main components.

### Why?
Systematised material circulation can improve material quality and choosing the right strategy can support efficient use of resources. Repurposing materials can open up for exploration of new properties, purposes and sensorial expressions, while mechanical and chemical recycling can convert materials from recovered products.

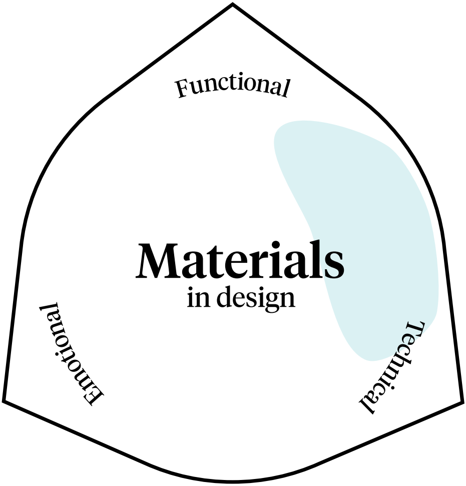
### Challenges
- Material circulation is not always cost effective. For chemical recycling of PET, only large-scale plants (50,000 tons/year) are cost efficient.
- Mixed materials can be difficult to separate into individual material streams and non-toxic materials can contaminate other materials.
- Most recirculating processes reduce material properties, so recirculated materials can be less durable and less longer lasting.

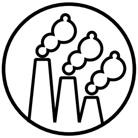
### Examples
- IonCell is an emerging process that chemically recycles cellulose waste.
- The Mater Ocean chair is made out of mechanically recycled nylon.
- Emily Bode specialises in repurposing rare and forgotten textiles into contemporary unisex workwear garments.

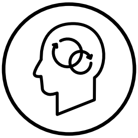
### This Card Links To
Material Composite / Material Degradation / Material Plurality / Material Scarcity / Material Transparency / Material Waste

### Further Reading
Aguirre (2006). Design for Repurposing: A sustainable design strategy for product life and beyond. University of Monterrey / Ashby (2013). End of First Life: A Problem or a Resource (Chapter 4). In: Materials and the Environment: Eco-Informed Material Choice. Butterworth-Heinemann, pp. 79–97 / Ragaert, Delva & van Geem (2017). Mechanical and Chemical Recycling of Solid Plastic Waste. Waste Management 69, pp. 24–58.

# Material Composite





# Material Composite

## What?

Composites are materials made out of two or more distinguishable materials that each contribute with specific functions. In that way, it is possible to customise materials by combining materials with different properties. A commercial group of composites for product design is called Wood-Fibre Composites. These are predominantly made of renewable and degradable resources.

## Why?

Composites make it possible to customise materials for specific applications, e.g. by high strength, low weight and durability. Furthermore, by working with the composition of materials, non-homogeneous and topology optimised materials can be obtained.

## Challenges

- To utilise a composite's elements best, it should be developed for a specific product. This can make development time-consuming and costly.
- Composites are difficult to disassemble and thereby material recycling can be complicated.

## Examples

- Animal bones are made of hard and brittle hydroxyapatite and soft and flexible collagen.
- Most of the Airbus A350 XWB's wing and frame is comprised of lightweight carbon composites that due to the lighter weight, require less fuel to move.
- The core of the iconic Panton chair manufactured by Vitra is made of glass-fibre reinforced polyester.

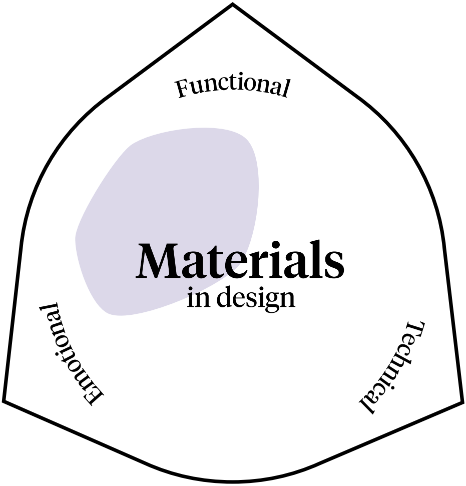
## This Card Links To

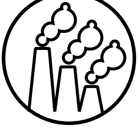
Material Biomimicry / Material Circulation / Material Degradation / Material Plurality / Material Substitution / Material Waste

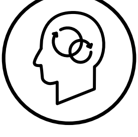
## Further Reading

Bunsell & Renard. (2005). Fundamentals of Fibre Reinforced Composite Materials. Series in Materials Science and Engineering. Taylor & Francis / Callister (2006). Composites (Chapter 16). In: Materials Science and Engineering, Wiley and Sons, pp. 577–620.

# Material Crafting





# Material Crafting

### What?
Material crafting revolves around knowledge, skills and experience in relation to material properties, behaviours and potentials. It is about making or working with materials as well as the potential for craft practice to foster collaborative communities.

### Why?
Material crafting can support resilience at individual, communal and societal levels and can contribute to creating meaningful relationships with materials. It provides an alternative to mass-production that can support small and local enterprise practices and combined with digital practice, it can help preserve cultural heritage.

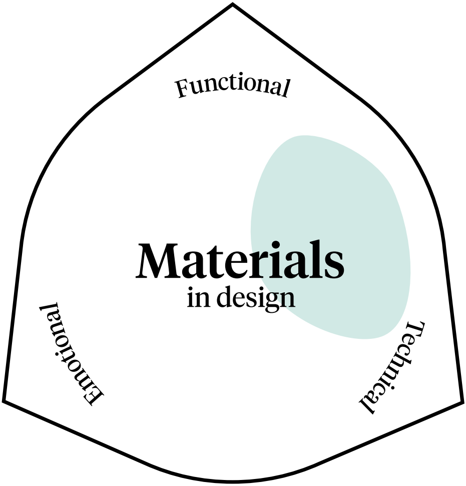
### Challenges
- It may be challenging to compete with mass-production.
- Ethical collaboration when working alongside craftspeople and communities.
- Users might find it challenging to engage with craft techniques.

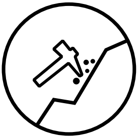
### Examples
- CUCULA Refugee Company for Crafts and Design aims to show how craft, design and material histories can have a positive social impact.
- Designer Rosa Tolnov Clausen uses textile craft as a catalyst for physical, social and creative interaction.
- Alei Verspoor's Modern Modular Craft project explores how to combine modular design with co-design and ancient crafts techniques to create repairable circular economy products.

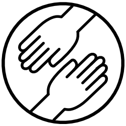
### This Card Links To
Living Material / Material Ageing / Material DIY / Material Geography / Material Perception / Material Sensing / Material Speculation / Material Tinkering

### Further Reading
Bernabei & Power (2018). Hybrid design: Combining craft and digital practice. Craft Research Volume 9 (1), pp. 119-134 / Reubens (2019). Holistic Sustainability Through Craft-Design Collaboration. Routledge / Sennett (2009). The Craftsman. Penguin Books.

# Material Degradation





# Material Degradation

### What?

Material degradation describes physical breakdown, the disintegration of materials' molecules into smaller molecules or fragments. Degradation can be initiated by external influences such as heat, moisture, chemicals, exposure to UV light, fungi or bacteria and is enhanced by mechanical stress. Bio-degradability and compostability are kinds of material degradation in specific environments.

### Why?

Understanding a material's degradation can help align material properties with a product's purpose and intended life span. Elaborate material degradation can be used to reduce waste build up. Degraded organic substances can provide soil and microorganisms with nutrients.

### Challenges

- Some materials degrade to micron-sized particles for example, microplastics, which are persistent in the environment and present a potential source of harm for organisms.
- Uncontrolled environmental conditions may result in loss of material properties and compromise the longevity and durability of the material.
- To distinguish the level of degradability.

### Examples

- Italian 3D printing company WASP have printed a house made from bio-degradable agricultural waste such as rice husks and straw.
- Freitag has developed F-abric, a 100% biodegradable fabric. Pieces are constructed with easily removable fastenings so that the garments can break down completely including the threads and selvage.

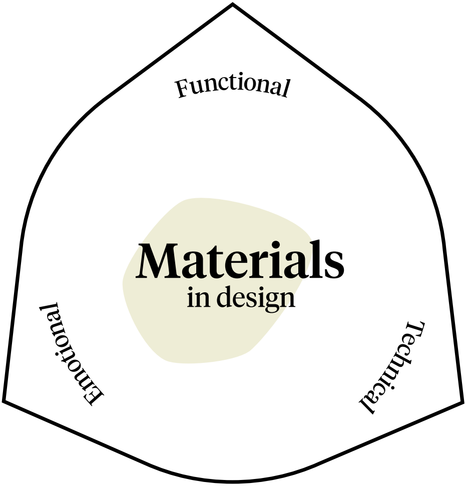
### This Card Links To

Material Ageing / Material Circulation / Material Composite / Material Plurality / Material Substitution / Material Transparency / Material Waste

### Further Reading

Garbage (1997). Introduction, In: Degradable Materials: Perspectives, Issues 6 Opportunities, pp. 1-10 / Jiang & Zhang (2012). Biodegradable Polymers and Polymer Blends. In: Ebnesajjad (ed.). Handbook of Biopolymers and Biodegradable Plastics: Properties, Processing and Applications, Elsevier, pp. 109-128.

# Material DIY




# Material DIY

### What?
Material DIY is a methodical design approach that puts the material in focus and where new materials from a designer's perspective can be explored or existing materials can be altered or developed further. DIY materials can result in functional and environmentally-friendly material developments, to provocative and speculative uses of materials.

### Why?
Material DIY promotes tangible access to materials without industrial middlemen and challenges conventional mass-production practices. Thus, it can disrupt how materials are usually perceived and experienced in everyday objects, e.g. through alternative aesthetics. Self-production activities might increase material awareness and appreciation through user engagement and can help to see new potentials in material resources.

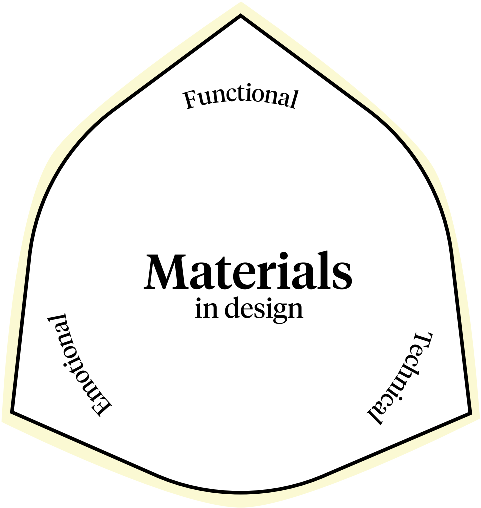
### Challenges
- The functionality and aesthetic vision might be compromised.
- It can require further collaboration with other actors such as chemists, biologists and farmers.
- It can be laborious due to a craft-based nature and it can thus be challenging to produce larger quantities.

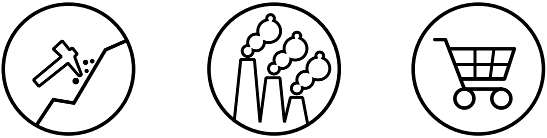
### Examples
- The Grow It Yourself mycelium-based home kit allows anyone to grow their own creation.
- The web platform Materiom offers a wide selection of recipes for material exploration.
- In the European project Material Designers, 120 designers were invited to material exploration workshops.

### This Card Links To
Living Material / Material Crafting / Material Perception / Material Sensing / Material Speculation / Material Tinkering

### Further Reading
Ayala-Garcia & Rognoli (2017). The New Aesthetic of DIY-Materials. The Design Journal, 20:sup1 / Rognoli, Bianchini, Maffei & Karana (2015). DIY Materials. The Journal of Materials and Design, 86, pp. 692-702.

# Material Geography



# Material Geography

## What?

Material geography considers the geographical journeys materials have undertaken through sourcing and production. This covers aspects of local sourcing and production, but also how a globalised production system gives easy access to geographically distant resources.

## Why?

Material geography can minimise use of resources i.e. transport cost, CO2 emission and support user understanding through transparency within the supply chain. Furthermore, it can create awareness on mono-cultural production, loss of biodiversity and building material resilience.

## Challenges

- It is not always easy to gain insights on material origin and their production process and thus to influence it when sourcing.
- Minimising material flows may limit material diversity and quantities, and cost of materials could be significantly higher.

## Examples

- Atelier NL develops tangible, everyday objects that illustrate the value of local raw materials both in sourcing and production.
- India Flint experiments symbiotically with local plants to discover colours and develop eco-prints to tell narratives of her environment.
- The Bottle-Up initiative in Zanzibar employs local craftsmen to transform the substantial glass waste.

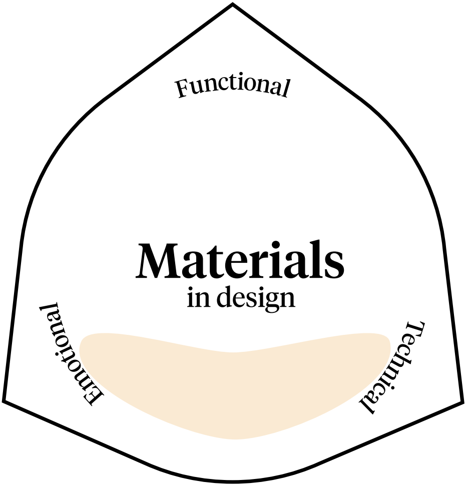
## This Card Links To

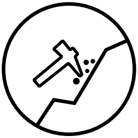
Material Bio-Ecology / Material Circulation / Material Crafting / Material Origin / Material Plurality / Material Scarcity / Material Transparency

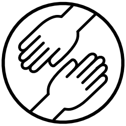
## Further Reading

Bridge (2011). Resource geographies 1: Making carbon economies, old and new. Progress in Human Geography 35 (6), pp. 820–34 / Cullen, Allwood & Bambach (2012). Mapping the global flow of steel: from steelmaking to end-use goods. Environmental science & technology 46 (24), pp. 13048–55 / Manzini (2016). Resilient systems and cosmopolitan localism — The emerging scenario of the small, local, open and connected space.

# Material Origin





# Material Origin

## What?

Material origin considers how the origin of a material influences its further need for processing and use and how traceable this is in the appearance of the material. Many materials of both organic and inorganic origin are sourced directly from nature, such as cork harvested from cork oak trees and granite mined from quarries.

## Why?

Although all materials in some way derive from nature, natural materials are generally subjected to less treatment and processing than man-made materials. Furthermore, familiarity with a material's origin can enhance emotional connection to an object.

## Challenges

- Organic natural materials can undergo fading, yellowing, or embrittlement in response to prolonged exposure to light and heat.
- To grow, harvest and extract natural materials in a way whereby the ecological systems they exist within are sustained.

## Examples

- Ana Mestre's focus on designing living objects in the Portuguese Corque Design project.
- Hemp Bio Leather is a by-product from the hemp, food and agriculture industry in Denmark.
- Fibreshed is an organisation that explores localising the entire growing, making and dyeing process of a garment/textile.

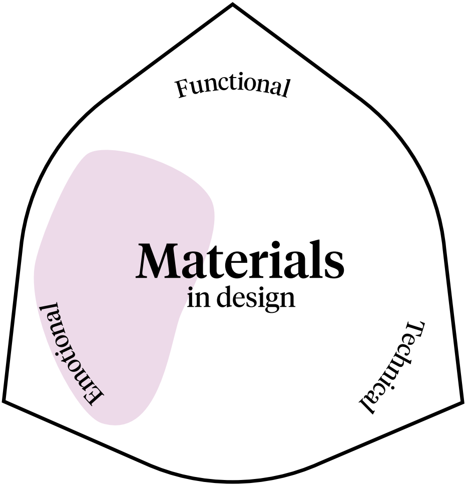
## This Card Links To

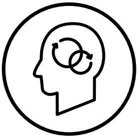
Material Bio-Ecology / Material Circulation / Material Geography / Material Perception / Material Plurality / Material Scarcity / Material Transparency / Material Waste

## Further Reading

DeMouthe (2006). Natural Materials: Sources, Properties, and Uses, Architectural Press / Lefteri (2014). Section 1 – Grown and Section 3 – Mined in: Materials in Design, Laurence King Publishers, pp. 14-95, 160-241 / Mestre (2014). Cork Design: A Design Action Intervention Approach Towards Sustainable Product Innovation (PhD dissertation). Delft University of Technology.

# Material Perception



# Material Perception

### What?

Material perception explores and considers the ways that materials carry cultural narratives embedded with values and meanings linked to production and use.

### Why?

Awareness of cultural values and meanings embedded in materials can facilitate meaningful designs and help in choosing relevant materials within contexts. Understanding cultural material narratives can also be used to challenge and problematise inherent material perceptions and seeing new material potentials in waste-streams.

### Challenges

- Understanding materials culturally, particularily from within a culture.
- Awareness and willingness of people who work with materials to reflect the material choices.
- To challenge pre-conceived notions about material applications and value.

### Examples

- Jane Norris' research on spoons as 'narrative vehicles' to communicate our cultural values in different times.
- The Merdacotta concept is challenging common perceptions of cow dung through giving a second life to the material in tableware.
- Billie Van Katwijk's Ventri design project explores what happens to the value of a perceived waste material like cow stomach when brought into a luxury context.

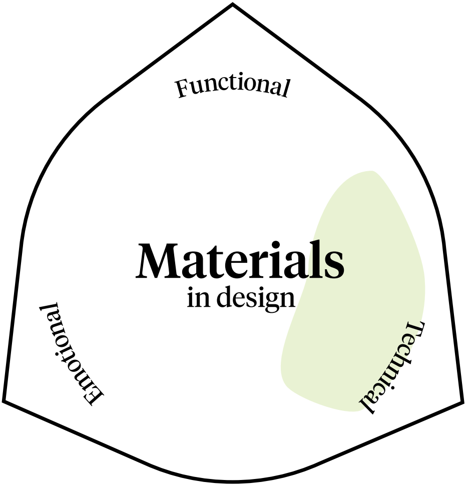
### This Card Links To

Living Material / Material Ageing / Material Crafting / Material DIY / Material Origin / Material Responsivity / Material Sensing / Material mater / Material Substitution / Material Tinkering / Material Waste

### Further Reading

Bennett (2010). Vibrant Matter: A Political Ecology of Things. Duke University Press / Norris (2017). Polychronic Spoon Stories – Material Narrative in multi-temporal designing. Research Trough Design Conference, Edinburgh.

# Material Plurality




# Material Plurality

### What?
Material plurality considers the use of different materials in products due to the need for material functionalities. Sometimes this is also called 'material diversity'. An approach to this is working with mono-materials, where a single type of material is used for each component of a product so that it can be split apart after use.

### Why?
Many products have multiple technical, functional and emotional aspects, which can be supported by using many different materials in one product. This however creates highly complex products.

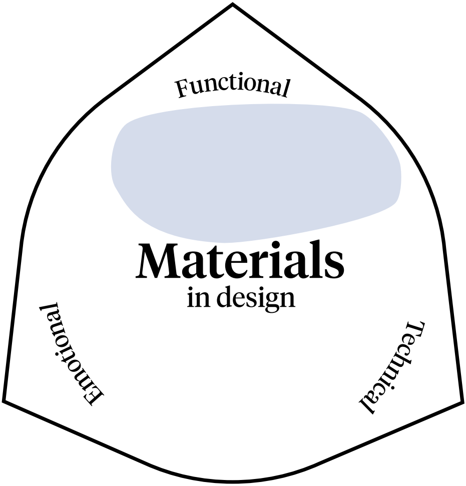
### Challenges
- Material plurality in products challenges repair, re-use and disassembly. If products are designed to be disassembled, it is necessary to clearly inform on the materials used.
- It may be necessary to compromise on functionality and aesthetics to lower the number of materials in a product.

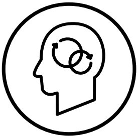
### Examples
- Lilian van Daal's chair concept utilises biomimicry and 3D printing to provide a mono-material alternative for conventional soft seating.
- In jumbo aircrafts, there are between 3,000,000 and 7,000,000 components.
- Product teardown is an approach to understand a product's parts, the materials they're made of and to reverse engineer an alternative product.

### This Card Links To
Material Circulation / Material Composite / Material Degradation / Material Origin / Material Scarcity / Material Substitution / Material Transparency / Material Waste

### Further Reading
McDonough & Braungart (2002). Cradle to Cradle: Remaking the Way We Make Things. North Point Press / Parajuly & Wenzel (2017). Product Family Approach in E-Waste Management: A Conceptual Framework for Circular Economy. Sustainability 9 (5), pp. 768-781.

# Material Responsivity



# Material Responsivity

### What?
Material responsivity is materials' capability to change one or more properties when impacted by a defined stimulus. Stimulus can e.g. be heat, electricity, chemicals, moisture, UV-light, pressure. The response manifests changes in a material's molecular structure due to higher or lower energy levels of the material.

### Why?
It is possible to program responsive materials to shift modus under specific conditions. It can thus lead to less material use by e.g. promoting multi-functionality. Furthermore, responsive materials support complex operations in products that are difficult to mechanically construct.

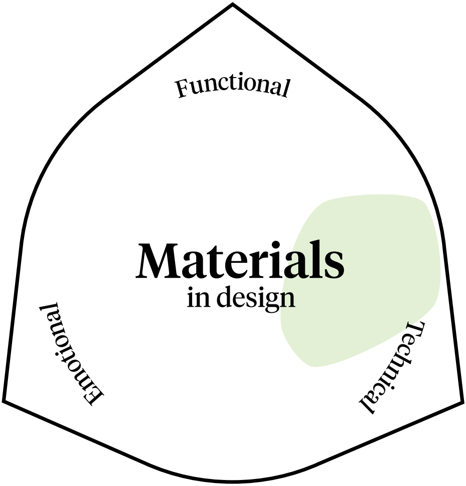
### Challenges
- Materials might be expensive or require high levels of technological understanding.
- Materials might not be environmentally friendly due to e.g. material origin, technologies or chemicals used in production and material 'hybrids' might compromise recyclability.
- Sometimes responsive materials have more of a 'gimmicky' effect in products.

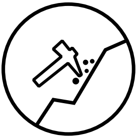
### Examples
- MIT's Self-Assembly Lab has developed an auxetic material that can automatically respond to changes in temperature by expanding at high temperature and contracting at low temperature.
- Marjan Kooroshnia has explored the design properties and potentials of colour-changing effects with leuco dye-based thermochromic inks when printed on textiles.

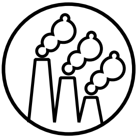
### This Card Links To
Material Biomimicry / Material Perception / Material Sensing / Material Speculation

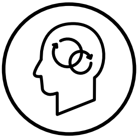
### Further Reading
Tibbits (2017). Active Matter. MIT Press / Tiwari & Kobayashi (eds). (2014). Responsive materials and methods: state-of-the-art stimuli-responsive materials and their applications. Scrivener Publishing.

# Material Scarcity







# Material Scarcity

### What?

Material scarcity considers our need and dependency of current and future materials (e.g. for consumer electronics and electric cars), hereunder those that are increasingly difficult to source due to political, economic, technical or environmental challenges. This is also called ‘material criticality’.

### Why?

The more difficult it becomes to extract certain raw materials, the more vital it is to consider challenges of scarce materials through circular design solutions, efficient resource use and optimised product lifespans, design for disassembly and recycling and to substitute and promote research on alternative material resources.

### Challenges?

- Missing or insufficient systems (both infrastructural and product systems) for reclaiming materials from waste.
- As some materials become scarce, who decides which uses are prioritised and who has access to them?
- Designing technologies that allow disassembly might compromise technological functionality.

### Examples

- The Rare Earthenware project by studio Unknown Fields Division
- Jorien Wiltenburg's Micro Urban Mining: Extracting electronic waste
- Fairphone's takeback system for old phones to enhance material reuse.

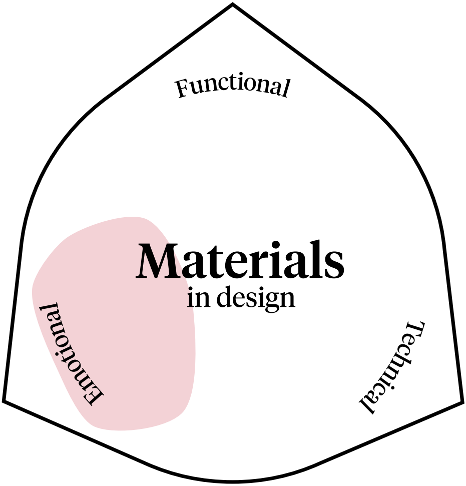
### This Card Links To

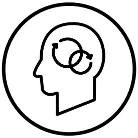
Bio-Synthetic Material / Material Circulation / Material Degradation / Material Geography / Material Origin / Material Plurality / Material Substitution / Material Transparency/ Material Waste

### Further Reading

Ashby (2013). Resource Consumption and Its Drivers (Chapter 2). In: Materials and the Environment: Eco-Informed Material Choice. Butterworth-Heinemann, pp.15–48 / Fitzpatrick (2017). Conflict minerals and the politics of stuff (Chapter 13). In: Chapman (ed.). Routledge Handbook of Sustainable Product Design. Routledge, pp. 197-205 / Graedel et al. (2012). Methodology of Metal Criticality Determination. Environmental Science & Technology 46(2), pp. 1063–70.

# Material Sensing



# Material Sensing

### What?

Material sensing is about activating and evoking sensory perceptions and emotions in users through material experiences and thus link physical interactions with materials to deeper reflections on material affections.

### Why?

As material sensing links to our understanding of the world, it can help build meanings and bonds with materials and objects.

### Challenges

- Material sensing and meaning creation is subjective and is anchored in both the individual and the culture. Thus, experiential aspects of materials are difficult to generalise and are therefore time consuming to become attuned to.
- There is a lack of general guidelines and tools to combine material experience with more objective aspects of material selection and development.

### Examples

- Studio Omer Polak's audio-olfactory installation, Olfactory Forest, poses questions about what a near-total deforestation could cause.
- The repertory grid by Anne Louise Bang aims to facilitate dialogues about the emotional value of textiles.
- In the Softie Wanted project by Victoria Ledig and Mandy Roos, material experience is in main focus. Through material responsiveness and tactility, users are invited to interact with the design.

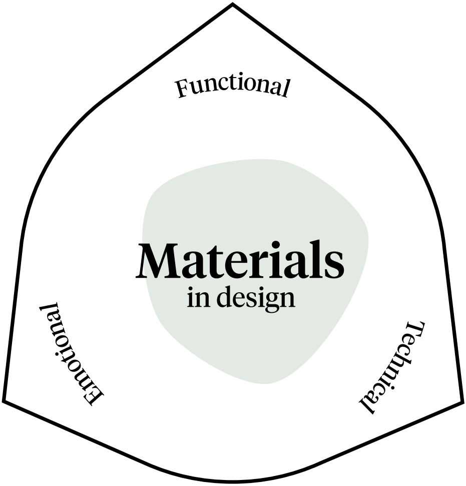
### This Card Links To

Material Ageing / Material Crafting / Material DIY / Material Perception / Material Responsivity / Material Tinkering

### Further Reading

Crippa, Rognoli & Levi (2012). Materials and Emotions: A Study on the Relations Between Materials and Emotions in Industrial Products, Proceedings of 8th International Design and Emotion Conference, London UK / Karana, Pedgley & Rognoli (2014). Materials Experience: Fundamentals of Materials and Design. Butterworth-Heinemann / Zuo et al (2016). Sensory Perception of Material Texture in Consumer Products. Design Journal 19(3), pp. 405–27.

# Material Speculation



# Material Speculation

### What?

Often inspired by science and technology, speculative materials embody tangible or virtual artefacts around the concept of a possible or imagined world.

### Why?

Material speculation is a way to induct critical investigation and inquiry of our present world. The output of the materials may propel thinking, evoke curiosity, open discussions, and raise awareness and questions at individual, communal and societal levels. It can also foster awareness in relation to a utopian or dystopian future.

### Challenges

- How to disseminate the material and the context in which it was explored or created.
- The position calls for a level of viewer imagination and understanding of context.
- Technology and physical requirements for creating speculative materials may be limited e.g. labs, machinery.
- Cross-disciplinary collaboration may be required to take material exploration further.

### Examples

- Faber Futures is a biodesign futures agency that have experimented with dyeing fabric with bacteria.
- The Design out Waste project by The Agency of Design speculates on what to do with old electronic devices.

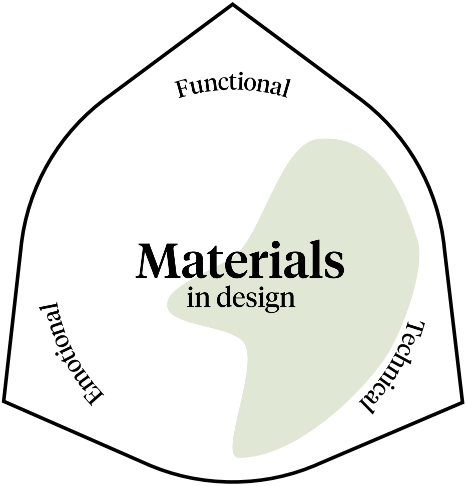
### This Card Links To

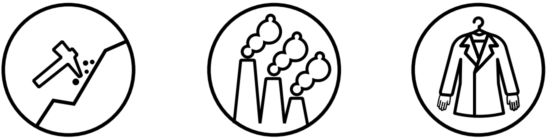
Bio-Synthetic Material / Living Material / Material Biomimicry / Material Crafting / Material DIY / Material Perception / Material Responsivity

### Further Reading

Auger & James (2013). Speculative Design: Crafting the Speculation. Digital Creativity. 24(1), pp. 11-35 / Coraglia & Di Giorgi (2019). The role of design in discovering speculative futures materials for local revaluation. Investigation of the methodology. The Design Journal 22:sup:1, pp. 1687–95 / Dunne & Raby (2013). Speculative Everything. MIT Press.

# Material Substitution



# Material Substitution

## What?

Materials that are developed or promoted to substitute another due to e.g. functional, environmental, ethical, legal, economic or cultural concerns and the possible changed practices due to material substitution. A common material substitute is that of vegan alternatives to animal-based products such as meat and leather.

## Why?

Material substitution is a result of an ever-changing dynamic society. Here the availability of different material substitutes can both challenge and stabilise markets.

## Challenges

- A material's technical, functional and emotional aspects can be compromised.
- Material substitutes can be more expensive and difficult to get hold of.
- Lack of transparency/information may contribute to 'green washing'.
- It is necessary to have a holistic approach to material substitution as other aspects may become problematic.

## Examples

- Piñatex, a leather alternative, is a by-product of the pineapple harvest that provides positive social and economic impact.
- With peace silk, the silkworm is allowed to emerge naturally from the cocoon before the leftover material resource is spun together.
- In a EU directive aiming to lower energy consumption for electronic household goods, the maximum hoover engine power was lowered from 1600W (2014) to 900W (2017).

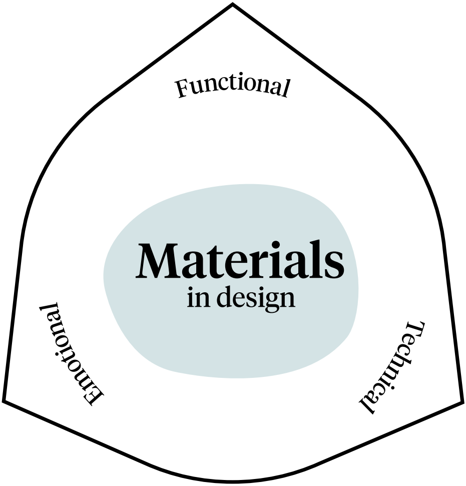
## This Card Links To

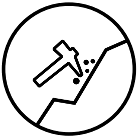
Bio-Synthetic Material / Material Biomimicry / Material Composite / Material Degradation / Material Origin / Material Perception / Material Plurality

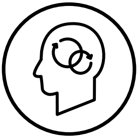
## Further Reading

Bontempi (2017). Raw Materials Substitution Sustainability. Springer / Twine (2017). Materially Constituting a Sustainable Food Transition: The Case of Vegan Eating Practice. Sociology 52(1), pp. 166–81.

# Material Tinkering





# Material Tinkering

### What?
With material tinkering, a wished-for sensitivity to different properties and qualities of materials are developed through hands-on experimentation. Using different techniques, materials' functional and sensorial aspects can be jointly explored and unfolded creating a shared vision for the material.

### Why?
It can provide relevant information on material properties and characteristics through experimental practice and it can thus aid material selection with essential aspects of meaningful material experiences. Furthermore, it can stimulate development of new materials and creative repurposing of waste-stream materials.

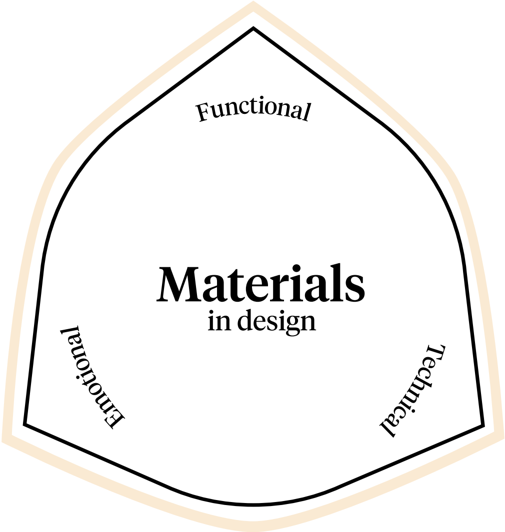
### Challenges
- There is a lack of general guidelines, rules, toolkits and methodologies.
- Direct experimentation with certain materials might be hazardous, e.g. tinkering with materials that are toxic or might release toxins in the tinkering process.
- Letting the material lead the way might challenge the traditional design process and thinking.

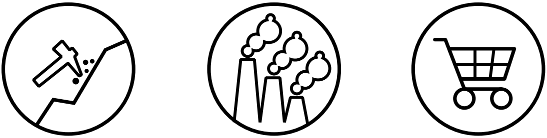
### Examples
- Sophie Rowley's Material Illusions experiments with waste materials through tinkering and craftsmanship.
- Joining Bottles by Micaella Pedros explores the possibilities and limits of repurposing plastic bottles as joining materials.
- In Inga Kristín Guðlaugsdóttir and Elín S. Harðardóttir's Lupine Project explores lupin to provide an alternative for conventional materials.

### This Card Links To
Bio-Synthetic Material / Living Material / Material Crafting / Material DIY / Material Perception / Material Sensing / Material Waste

### Further Reading
Parisi, Rognoli & Sonneveld (2017). Material Tinkering. An inspirational approach for experiential learning and envisioning in product design education. The Design Journal, 20:sup1, S1167-S1184.

# Material Transparency



# Material Transparency

### What?
Material transparency is concerned with negative environmental and/or social impact that occurs in non-transparent material economies from material resource extraction to material disposal.

### Why?
Uncovering and trying to understand traces of materials and how these link to economic interests can raise awareness of unethical or unfruitful implications of material dealings in a global economy. Furthermore, building knowledge on the implications of material economies can qualify ethical reflection in material choices and insights can lead to sourcing and production innovation.

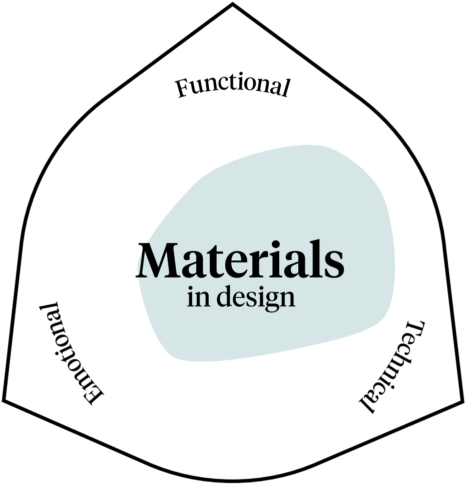
### Challenges
- The market is non-transparent and the global material trajectories are extremely complex.
- Different actors might have different interests, which influences the trajectory of the resource.

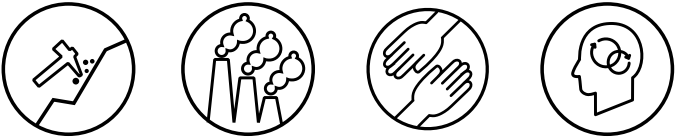
### Examples
- The Reversed Resources organisation have shown how, in Bangladesh, a black economy trading in textile production spillage, prevents circular systems innovation, and thus proposed a new pricing system.
- The mining of raw materials for electronic products contributes to respiratory health issues for workers in the mines, as well polluting water in surrounding communities and generating large amounts of waste.

### This Card Links To
Material Bio-Ecology / Material Circulation / Material Degradation / Material Geography / Material Origin / Material Plurality / Material Scarcity / Material Substitution / Material Waste

### Further Reading
Bunker & Ciccantell (2015). Globalisation and the Race for Resources, John Hopkins University Press / Julier (2017). Economies of Design. SAGE / Souffrant (2019). Global Development Ethics. A critique of Global Capitalism. Rowan & Littlefield / Yusoff (2018). A Billion Black Anthropocenes or None, University of Minnesota Press.

# Material Waste



# Material Waste

### What?

Material waste considers any resource consumption and waste generation throughout a product lifecycle and how these should be enclosed in a system. This includes upcycling otherwise unvalued leftover waste material and zero waste approaches to optimise utilisation of resources.

### Why?

When considering waste as a valuable resource instead of something to get rid of, the incentive for reintroducing it in a purposeful application is increased. This can minimise the use of and prevent premature disposal and instead add multiple loops to the lifespan of materials.

### Challenges

- It is difficult to prevent contamination and breakdown of material resources.
- It requires co-thinking design, production, use and disposal.
- Transparency throughout the product lifecycle is essential.

### Examples

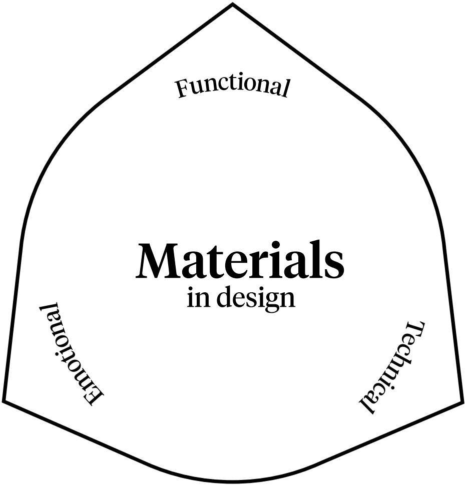
- 3D printing techniques from e.g. Materialise can be using multiple materials and offer efficient use of materials as well as potential reuse of excess materials.
- WasteBasedBricks are a combination of clay bricks, glass, ceramics and insulation that are waste materials generated from a local factory.
- Pure Waste re-spins waste yarns and off-cuts from pre-consumer waste in order to create fully-recycled knitted and woven garments.

### This Card Links To

Living Material / Material Circulation / Material Composite / Material Degradation / Material Origin / Material Perception / Material Plurality / Material Scarcity / Material Transparency

### Further Reading

Kottaridou & Bofylatos (2019). Design out waste methodology for circular economy, In: Proceedings of Responsive Cities. Disrupting through circular design, Barcelona, Spain, pp. 1-12 / Laitala et al. (2015). Making Clothing Last: A Design Approach for Reducing the Environmental Impacts. International Journal of Design 9(2), pp. 93-107 / McDonough & Braungart (2013). The Upcycle: Beyond Sustainability – Design for Abundance, North Point Press.


Functional
Materials
in design
Emotional
Technical

## What?

## Why?

## Challenges

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## Examples

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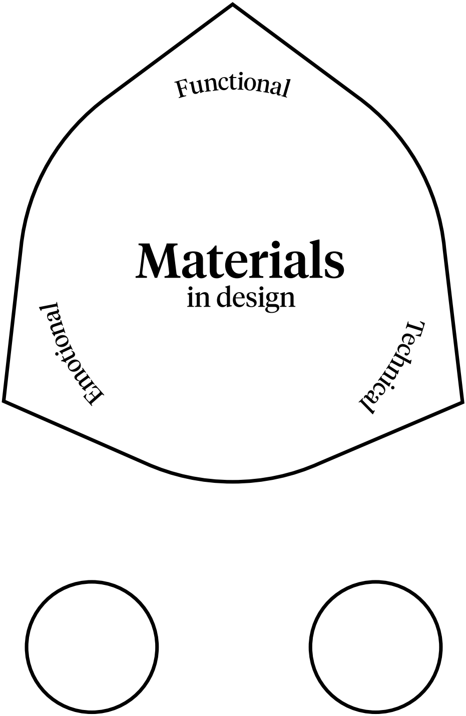
## This Card Links To

## Further Reading


Functional
Materials
in design
Emotional
Technical

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## What?

## Why?

## Challenges

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## Examples

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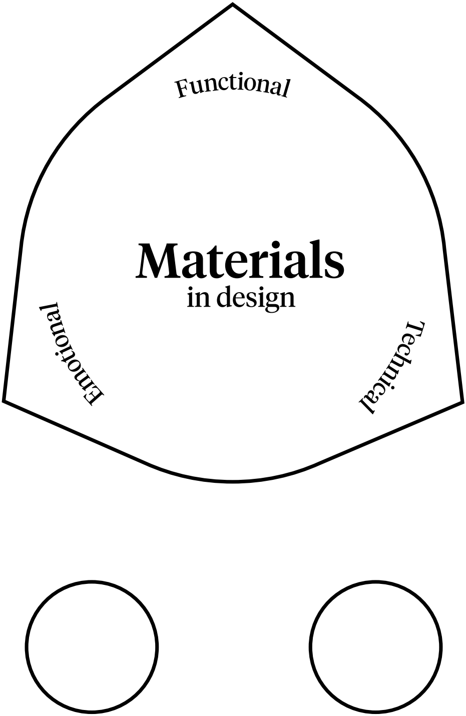
## Further Reading


Functional
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## What?

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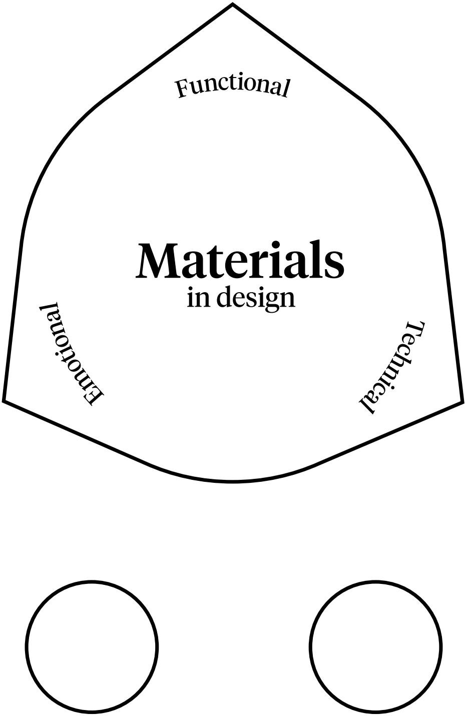
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## What?

## Why?

## Challenges

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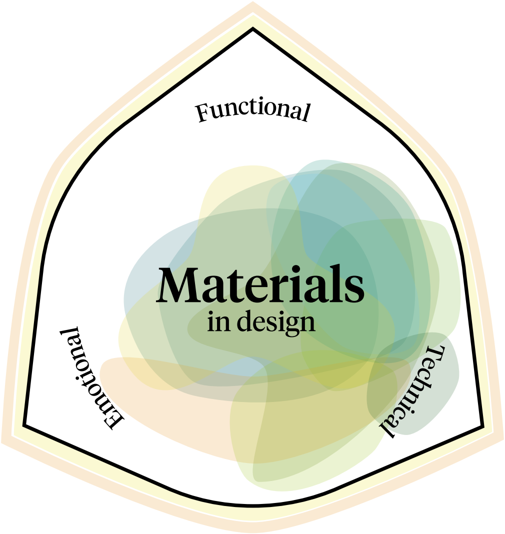
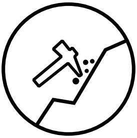
## This Card Links To

## Further Reading

www.materialpathways.dk

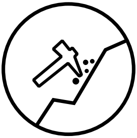
# Raw Materials



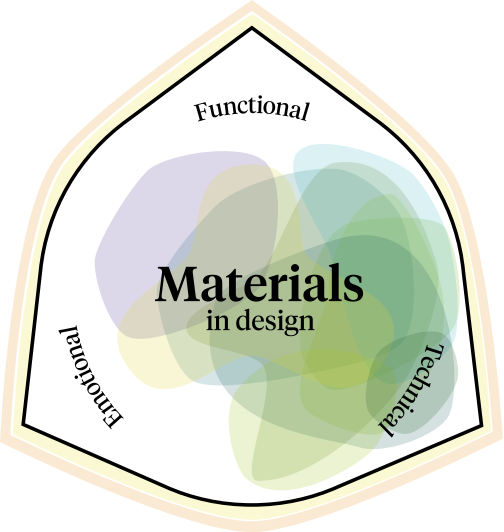



# Raw Materials

- Bio-Synthetic Material
- Living Material
- Material Bio-Ecology
- Material Biomimicry
- Material Degradation
- Material Geography
- Material Origin
- Material Scarcity
- Material Substitution
- Material Tinkering
- Material Transparency
- Material Waste



# Manufacturing & Production



# Manufacturing & Production

- Bio-Synthetic Material
- Living Material
- Material Bio-Ecology
- Material Circulation
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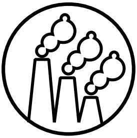
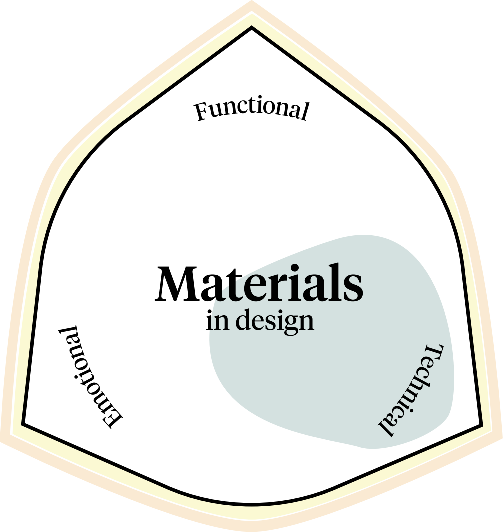


# Transport and Retail

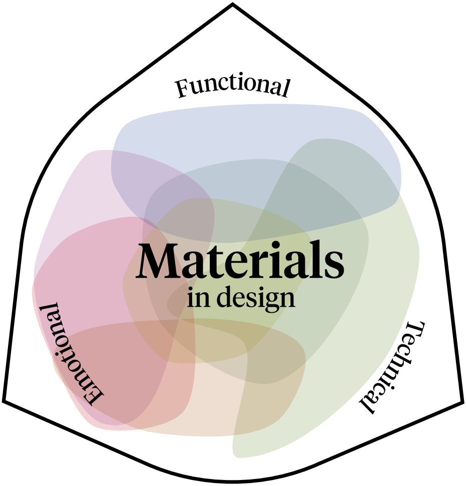



design school kolding

# Transport and Retail

- Material Circulation
- Material Geography
- Material Transparency

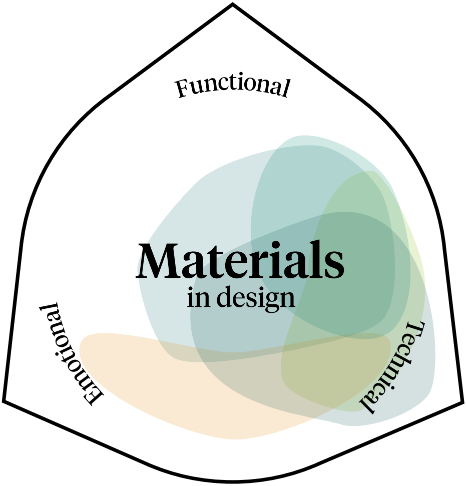
# User and Practice

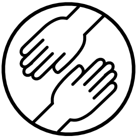



# User and Practice

- Material Ageing
- Material DIY
- Material Perception
- Material Responsivity
- Material Sensing
- Material Speculation
- Material Substitution

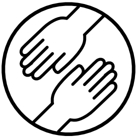
# Disposal and Recovery



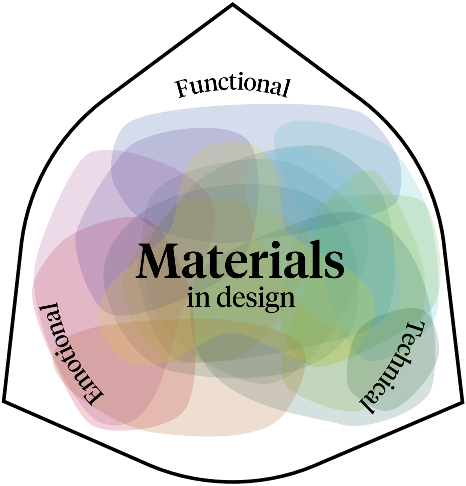



# Disposal and Recovery

- Material Circulation
- Material Composite
- Material Degradation
- Material Origin
- Material Plurality
- Material Waste

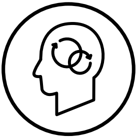


# Design and Concept

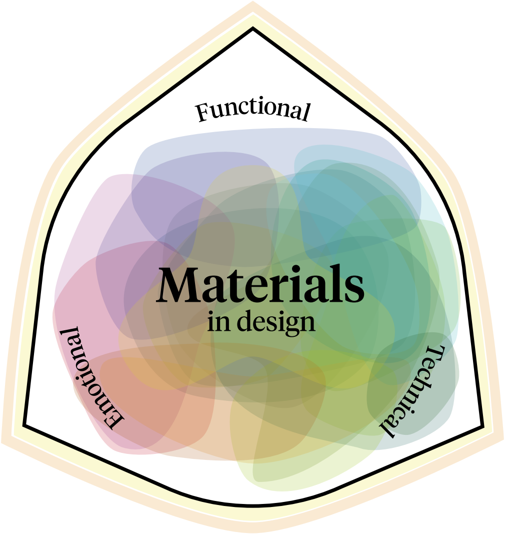


# Design and Concept

- Living Material
- Material Ageing
- Material Biomimicry
- Material Circulation
- Material Composite
- Material Crafting
- Material DIY
- Material Perception
- Material Plurality
- Material Responsivity
- Material Scarcity
- Material Sensing
- Material Speculation
- Material Tinkering
- Material Waste

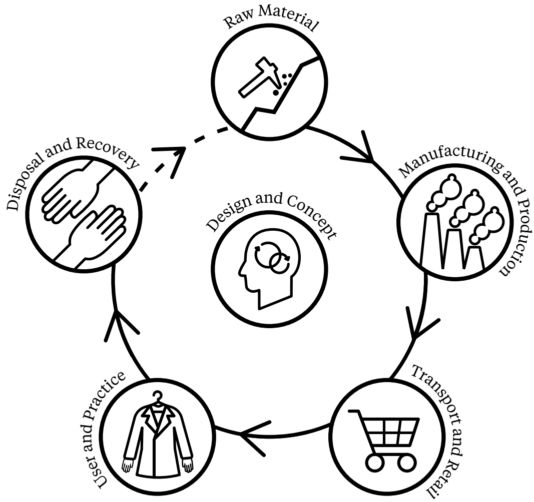


# Overview



# Overview

- Bio-Synthetic Material
- Living Material
- Material Ageing
- Material Bio-Ecology
- Material Biomimicry
- Material Circulation
- Material Composite
- Material Crafting
- Material Degradation
- Material DIY
- Material Geography
- Material Origin
- Material Perception
- Material Plurality
- Material Responsivity
- Material Scarcity
- Material Sensing
- Material Speculation
- Material Substitution
- Material Tinkering
- Material Transparency
- Material Waste


Raw Material
Manufacturing and Production
Transport and Retail
User and Practice
Disposal and Recovery
Design and Concept

# Material Pathways

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