Dematerialized | Rematerialized

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We live in a material world, filled with stuff, from both natural and man-made materials. In this paper, we will explore new materials for a new age with hope of progress within two categories:

DEMATERIALIZED: How can materials and products streamline their materiality, reduce their footprint, and become more sustainable in a maxed-out world?

REMATERIALIZED: How can materials and products be rethought, remade, remanufactured with new ideas and processes to address sustainability and overconsumption?

Our design industry's focus on sustainability is multi-faceted, dealing with waste streams, material health and transparency, reducing carbon footprint, and biophilic design. More people including youth generations are emotionally invested in the future of our planet. We will re-examine materials used in design and question how we can move to a new model where materiality is an important change agent for good.

Anthropocene

According to scientists, we are living in The Anthropocene, a new era that shows evidence of mankind's damage to the planet. Our destructive behavior of abusing the earth for consumer purposes has been growing and is reaching peak havoc. Also known as the Plastic Age, where the infiltration of everlasting plastic is in our oceans, our earth, our food, water supplies, and in all living species. This is but one environmental crisis, and much of this has happened since the industrial revolution but more crucially since the advent of plastics in the mid 20th century.

Plastic was once seen as a hopeful and futuristic material, where we could make things that are durable, lightweight, and long-lasting. And yet today, plastic has become a divisive material, so often seen as cheap, disposable, and polluting – and it could very well be the fossil of the future. The longevity of the material is exactly its most challenging problem – scientists believe it takes about 1000 years for plastic to degrade in landfill. We in the design community have a responsibility to incorporate best practices for making products and built spaces that are healthy for occupants and the environment alike. This is especially true for manufacturers of consumer goods; we all are making things that impact generations to come and need to imagine a healthier future. A ground-breaking exhibition at the Triennale Museum in Milan called "Broken Nature" debuted in March 2019. This exhibit, curated by Paola Antonelli, focused on how design will take on human survival in the Anthropocene. It was a sprawling exhibit of over 100 projects encompassing all forms of human, animal, and plant ecosystems and how we can apply our collective resources to repair and possibly reverse the destruction we have done to our planet. The exhibit was also a call to action to build reparations through restorative design, so that we may heal the relationship with nature, as well as leave behind design solutions for future generations. This exhibit is one of many calls to action in the Anthropocene.

Biomaterials

Many projects in the exhibit tackled climate change and the role of biomaterials as a solution. This is a new area of practice where designers look to natural alternatives to synthetic materials that do not biodegrade, which is the greatest challenge of plastic. It should be said that emerging designers aren't waiting for these biomaterials, they are creating these themselves as a sort of activism. They are envisioning a world where biological fabrication replaces synthetic manufacturing. We have entered a new era of design called "Disruptive Materiality", where designers are cross pollinating with biosciences to reinvent materials. The global bioplastics industry is forecast to reach a market value of almost $43 billion by 2030. This suggests growing economic interest in bioplastics and confirms the desire by consumers for these new materials.

One natural resource emerging as the go-to ingredient for biomaterials is algae. It grows rapidly and is plentiful; we are even seeing more algae growth due to global warming. It could have multiple applications across design as it also eats carbon dioxide and releases oxygen. It is being considered for biofuel, beauty products, and food. The algae market will

be valued at almost 45 billion dollars by 2023. Designers are already working to develop biodegradable food packaging made from algae. One organization, Atelier Luma, is a collective in France who works with designers to explore the potential of growing algae locally as a replacement for oil-based plastics. Dutch design duo Klarenbeek & Dros collaborated with them to supply the algae, which is then mixed with biopolymers to produce a fully bio-sourced material. This team and product won the new materials prize at Dutch Design Week in 2018. The project proposes a new model of biofabrication and Biofacturing - or biological manufacturing, where we can now grow materials, objects, and of course food and drink. The goal here is to learn from nature, and to harness the intelligence of nature and how microbes grow to make things from living systems.

Another designer exploring biofabrication is Jen Keane, who works between science, tech, and craft. She is using new digital tools and bioscience to create new materials by controlling nature. Her project “This is Grown” is a microbial weaving system that grows bacteria on a loom-like framework threaded with yarn. She started manipulating the growth process of k.rhaeticus bacteria (which is used in Kombucha), to utilize it in a new form. The process allows for the natural properties of bacterial cellulose to weave a new type of material that is strong and lightweight and can be engineered with little or no waste. The shoe upper tongue was grown from these bacteria. It is grown in a single piece with no sewing and one continuous yarn held into place by the cellulose produced by the bacteria. The bacteria can then naturally degrade back into the environment after the product’s useful life. Other scientists, designers and companies are working on using bacteria to grow biodegradable bioplastics, including Puma and MIT.

Related to algae is kelp, which is a seaweed that grows all over the world. AlgiKnit has created a sneaker prototype made by kelp to seek new sources for alternative materials. From kelp, the team extracts a specific biopolymer which is then treated with salts to create compostable textiles, ready for production. By adding these types of salts to the seaweed base, the scientists extract the alginate biopolymer. The material is then dried into a powder and fused into yarns that are converted into several types of textiles and fabrics. Kelp has a lot of benefits for the environment. It’s inexpensive to farm, and some species of kelp grow faster even than bamboo. Also, farming kelp near cities can improve the quality of polluted water.

Dematerialized

We just looked at ideas for new materials in the Anthropocene and how one area of bio design is progressing. But how do we redesign the plastic age? With the advent of bioplastics, we can start moving towards a post-plastic world. Imagine synthetic plastics being a thing of the past! But we are not there yet. Today there are five trillion pieces of plastic floating in the ocean, and manufacturers are still making stuff from virgin plastic. There is an interim step we can take to reduce carbon footprint, reduce landfill waste, and reduce the amount of chemicals and materials used to make things: Dematerialized. Manufacturers are rethinking how we make some of the main ingredients of their products by dematerializing them. This is the practice of reducing the manufacturing footprint of the product to be more sustainable. As a result, companies are creating products that perform just as much as the predecessor but are doing so with less material. In many cases, companies are seeing big savings in energy and water use too. Let’s look at some examples of what other companies and designers are doing to dematerialize for the sake of sustainability.

While much use with bioplastics is still in exploratory mode and hasn’t transitioned into mass market consumer household goods, one company changing that is Lego. Lego has decided to start making their products with bioplastics, made from plant-based polyethylene, specifically ethanol produced from sugarcane. They started rolling these out in 2018 with tree, shrub, and leaf Lego at first, and are working to use bio and sustainable materials in all products and packaging by 2030. According to Lego, the new bio-based blocks will look and perform as traditional Lego, and consumers won’t notice a difference. Additionally, Lego has partnered with the World Wildlife Fund for Nature to support and help create demand for sustainably sourced plastic. They have also joined the Bioplastic Feedstock Alliance (BFA), an initiative of WWF, to source the raw materials sustainably and responsibly for the bioplastics industry through third party certification. Lego believes a new sustainable material must have a lighter footprint than the material it replaces across environmental impact areas such as fossil resource use and climate change.

Also working in bioplastics for consumer products is a design and research team called Crafting Plastics. They focus on design as revolution, rethinking the entire plastic economy. Their motto is “Enjoy your plastic without oil”. They have developed a 100% oil-free, bio-based, and compostable

material to replace typical plastic called Nuatan. It's made from renewable raw resources, is biodegradable, and leaves a no-waste footprint in nature. It can withstand temperatures of over 210 degrees Fahrenheit and has a lifespan up to 50 years depending on the blend composition. When put in an industrial composter, it degrades into water, carbon dioxide, and organic matter. The second generation of Nuatan, currently in development, will biodegrade in home compost, soil, and ocean water. Nuatan can be processed by standard plastic industry technologies like injection molding, 3D printing, extruding, CNC milling, laser cutting, heat pressing, etc. Crafting Plastics hopes that it will replace oil-based plastics as the material of the future.

Fashion is one of the most wasteful industries, with tons of products going into landfill each year – which includes shoes. In fact, 20 billion pairs of shoes are produced annually, with roughly 300 million pairs ending up in landfills after they have been worn and can last for millennia in a landfill. Designer Lucille Nguyen created modular shoes called "Up-Part" as a response to this throwaway culture of fast fashion. Nguyen designed the modular footwear to be everlasting, since the shoe parts are interchangeable and can be easily replaced. The intention is for the consumer to assemble the shoe based on design preference, where the elements snap, clip, or tie into place in infinite combinations. When one part gets damaged, it can be replaced without having to get rid of the rest of the shoe. This limits waste and each part is recyclable. This allows the user to keep the shoe elements longer if they can be reassembled as needed with repairs and fashion trend changes.

Many designers today are using technology to re-think material production. Digitalab, a product design studio in Portugal, has turned natural cork into thread, which can then be used to weave into sustainable textiles, furniture, and lighting. Much cork comes from Portugal, as the bark of a specific tree. Cork is harvested every nine years without a tree being felled, so it's already been a good natural and sustainable material. Cork is usually quite thick and used for floor tiles, wall panels, etc. We have seen thin cork veneers used as wallcovering, but we have yet to see cork become dematerialized so that it has new properties and applications. For their fiber project, the thread is made by injecting water vapor through cork pellets. This causes the pellets to expand, while the water bonds with the resin in the cork. The mixture is then pressed and combined with a base layer of cotton fabric to produce a thin sheet that can be cut to one millimeter thick. The resulting threads are then washed to increase their flexibility and elasticity. Most people know of cork's acoustic and thermal properties, but the designers learned that cork also absorbs carbon dioxide, making it a great material for reducing carbon footprint. The fiber industry in fashion has also been looking for alternatives to synthetic yarns. Bolt Threads, a biotech company created a new product called Microsilk. They reference biomimicry by looking at how spiders produce silk fibers to weave webs and use that data to remake fiber. They engineer proteins inspired by spider silk through yeast fermentation, and then extract the liquid silk protein and spin it into fiber, similarly to how rayon is made. It has similar properties to real silk such as high-tensile strength, elasticity, durability, and softness. Bolt Threads has partnerships with Patagonia and Stella McCartney and is hoping to branch out to more fashion brands.

One of the heavier materials to work with in the built environment is concrete. Engineers and designers have been working on how to dematerialize it so it can be lighter to use and have greater and more far-reaching applications, especially without having to be reinforced by steel. Enter ultra-high-performance concrete (UHPC). This material has desirable design features: high strength, high density, and is very durable. By dematerializing concrete, it opens new architectural possibilities for very thin structures and free form shapes yet maintains the structural strength of conventional concrete. Water density is reduced, compression strength is increased, and additives are not necessary and are eliminated. As a bonus, thin structures require less material and leave a smaller carbon footprint as ultra high-strength concrete has carbon dioxide reducing potential. Another aspect of dematerialization is the use of low-impact natural dyes, especially in creating products that typically need finishing, like woodwork. There has been much research into natural dyes created by fruits, vegetables, coffee, tea, and other food waste. When manufacturers create things made from synthetic materials, a lot of energy is used to homogenize color, especially if working with recycled plastics, even adding new pigments to mask variations. Designers who are interested in sustainability are forgoing this kind of pigmenting and opting instead to use natural pigments and not being concerned with variation. Snego, a Swedish toy company, is making children's building blocks with natural food pigments and found wood. The natural colors offer variation in hue and color value, which adds to the character rather than detracts. Others are exploring the use of natural dyes in textiles. Kukka, a design studio in Rotterdam, explores the use of dyeing textiles naturally with bacteria that produce pigment. The

project, called Living Color, explores alternatives to typical synthetic textile dyes. They determined how to grow bacteria as a dye method, and as a result the pigments found in some bacteria are biodegradable and eco-friendly. They also researched the optimum growth conditions for these bacterial pigments, as well as the possibilities of growing bacteria in patterns by subjecting them to sound frequencies, which is a form of science called Cymatics.

We are going to end our look at dematerialization with a look at product packaging. If you look at any household liquid product, chances are that it's made from 80% water. Designer Mirjam de Bruin questioned what if products were reduced to the rest of the 20% solid ingredients, and then the consumer adds water on their own? Once you've bought your shampoo or detergent pellets, you simply put them in a reusable bottle, and add water. This is a simple yet revolutionary concept that could change the world, as tremendous savings could be made in shipping with weights, carbon emissions, and pollution. We are already started to see household cleaning and beauty products following this model.

Rematerialized

Now we are going to look at Rematerialized, which rethinks how materials and products should be remade or remanufactured with new ideas and processes to address sustainability and over-consumption. When we create new materials from other older or more wasteful materials, we arecreating new value. This also contributes to the Circular economy, especially as waste should always be viewed as food for something new. We are also making the physical world more sustainable as well as smarter and hopefully able to counteract some of the damage we have done to our planet while advancing design of all disciplines. This is where consumerism, waste, and scrap culture, and the rematerializing of products intersect. In some cases, dematerialization is best, but for products already here, they can be given a new life rather than heading to landfill.

British footwear designer Helen Kirkum takes discarded sneakers, breaks them down into smaller components, and reconfigures them into new ones. She especially likes to use the mismatched shoes, where the Left or Right went missing from the pair, thus optimizing the potential of waste. Her goal is to create something different yet familiar, where the original sneaker was a product of commercial fashion, and yet remaster the design so that it is personal to the new owner. This could also be considered "Disruptive Materiality" like we see with the onset of bioplastics, but in a different way that addresses remixing existing materials as a new process. Gumshoe, a sneaker sole made from already-been-chewed gum is the first shoe made from 20% recycled chewing gum, reclaimed from the streets of Amsterdam. In the Netherlands, gum is the second biggest cause of litter on the street every year after cigarette butts. They have an ongoing campaign to collect the discarded gum off the streets at collection kiosks. This project was a collaboration between Gum-Tec, a company that makes this new sustainable material compound out of gum for the rubber industry, the city of Amsterdam, and fashion brand Explicit.

There is a sustainability movement now called "Zero-Waste", which addresses the issue that no waste should go into landfill and should be used to create something new. We see this movement both in the design industry, as well as the food industry. We are especially seeing a lot of examples today where waste scraps from food are in demand for creating new design solutions. One group of Italian students created "Peel Saver" - an ingenious idea grown from potatoes. The designers focused on how fruits and vegetables come in their own natural packaging. Potatoes, for examples, have a skin that we typically peel away for cooking. Rather than waste the peels, the thought is that they become packaging for the fast-food French-fry market, thus creating packaging from waste of that food itself. The potato peel is made up of starches and fiber, which after maceration and natural drying bond to each other and harden in a circular mold, which gives it its conical shape for the market. The resulting material is completely made of production waste and is 100% biodegradable. After being used, the packaging can be used for animal food or fertilizer for plants.

Mexican designer Fernando Laposse developed a naturally colorful surfacing material made with native Mexican corn husks, called "Totomoxtle". Inspired by the 60 species of indigenous corn in Mexico, Laposse used a variation of corn husks to create an alternative to wood veneer. He flattened and glued the husks onto fiberboard, which then get finished like veneer in small batches, which provide designs that look like marquetry or patterned inlays. The goal is to use these boards to create furniture, millwork, etc., all while finding a use for corn husk waste as well as promoting Mexico's ancient tradition of cultivating corn and creating craft. Totomoxtle is made in a partnership with indigenous farmers who have seen their way of life threatened by globalization and the practice of

farming genetically modified corn, which is a huge industry in Mexico. This project creates awareness of crop diversity and increases local employment based on this new craft to ensure farmers can keep planting their heirloom versions of corn. This is a great example of sustainability where materials intersect with culture and social justice.

Another botanical that is a growing source of bio-design is Mycelium, made from the root system of mushrooms. Mycelium is a wonder fungus because it absorbs carbon dioxide and could help offset climate change. It also is touted for medicinal and cosmetic use. They are a natural binder and are a spongy, foam-like material that is being grown into furniture, lighting, household objects, and clothing. Bolt Threads, who we mentioned earlier, is making a leather alternative called Mylo from mushrooms. Furniture designer Sebastian Cox with Ninela Ivanova staged a “biofacture lab” at 2017’s London Design Festival, growing lighting and stools from mycelium using salvaged timber for the structure. These kind of experiments of are just a few in an ever-growing field of design research, and we will be seeing a lot more mushroom based products in the future. Scientists have long been looking to the sea for sustainable solutions for the planet. Chitin is the second most abundant biopolymer in the world next to cellulose (the building block of all plants). Chitin, and its derivative chitosan, occur naturally as the building block of the shells of all crustaceans and of the exoskeletons of insects. Designers have started to focus their attention on chitosan as a sustainable resource of waste generated from the seafood industry. Shellworks, created by British design students, is product packaging made from discarded lobster shells. The chitan gets mixed with vinegar to form a thin paper-like material that will become an alternative to single use plastics.

Another bioplastic made by researchers at Harvard's Wyss Institute for Biologically Inspired Engineering is created from shrimp shells by isolating the chitosan and forming a laminate with silk protein. The new material, called “Shrilk”, can be used to make objects that biodegrade when placed in compost. Because chitosan and the silk protein are both used in FDA-approved devices, Shrilk also may be useful for creating medically implantable devices and used for regenerative wound healing. We briefly mentioned earlier leather made from alternative sources like mycelium. This is seen as vegan design, where ethical sourcing of materials does not involve animals or the non-sustainable meat industry, which contributes to deforestation and climate change among other global and social challenges. And as we saw earlier, designers are exploring new materials made from plant life.

A new leather alternative made from pineapple leaf fiber is available now: Piñatex by a company called Ananas Anam. The leaves are the waste byproduct of the agriculture industry, and their use creates an additional income stream for farmers in the Philippines, where 40,000 tons of pineapple waste is generated every year. The pineapple leaves are gathered, then the cellulose fibers inside the leaves are removed and processed into a nonwoven textile, and then sent to Spain for finishing and distribution to fashion, footwear, and upholstery designers and manufacturers. The resulting leather alternative is breathable and flexible, can be sewn and printed on. It sells on a continuous roll like fabric, avoiding the waste caused by irregularly shaped leather hides, so you don’t have to order overage.

Our last example or rematerialized is by Beer Holthuis, who 3D prints objects from paper pulp. Paper destined for the recycling bin is one of the most abundant and easily accessible raw materials. Add a little bit of a natural binder, and you get a good material for 3D printing. Today, almost all the material used for 3D printing is virgin synthetic plastic. Sustainable materials for 3D printing haven’t yet infiltrated this market. However, 3D printing has revolutionized design, allowing the democratization of design where anyone can make anything within the limits of the machine and the materials. And now designers are experimenting with printing on demand in new materials. Holthuis is hoping this simple swap of materials could revolutionize design and 3D printing.

Conclusion

We are living in a time of great change, where the natural and digital worlds have collided, and humanity is facing uncertainty and turmoil. We have advances in technology and yet we also fall short of sustaining a healthy planet and population. It is time to dematerialize and rematerialize. Designers must question the status-quo of how objects are made and push for newer options that are safer, cleaner, and do no harm. Anyone in the design community has a responsibility to incorporate best practices for making products and built spaces that are healthy for occupants and the environment alike. Can we completely move to a new consumption and production model? The hope is visualizing a world beyond material waste and encountering solutions for positive impact and change.