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Commentary

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Cradle to Cradle: Why we need to rethink the way we produce

More and more people are worried about harmful chemicals in our products. A survey by Statista from 2017 showed that 84% of the respondents fully agree or tend to agree with the statement "I am concerned about the health effects of chemicals in everyday products." (Statista, 2017). This concern about harmful ingredients does not only show in surveys but also in the products consumers choose to buy. The market share of natural cosmetics for example has constantly been increasing in the last few years (EHI Retail Institute GmbH, 2022). More and more products are marked as "natural" or even "free of chemicals". In its extreme form, an aversion to chemicals can even lead to an irrational fear of chemicals, also called chemophobia (Saleh et al., 2020).

Why we love good chemicals

Of course, it is a positive development that there is an increasing discussion about what ingredients are actually in our products and about harmful chemicals in general. However, what tends to get lost in the public discussion is the fact that everything is chemical. Every person, every product is based on and needs carbon, the basis of organic chemistry. When we think about an apple or a flower, most people will probably not see these items as chemical products, but in fact they are also made of chemical elements. Chemistry or chemicals are not by definition harmful, whereas "natural" does not always mean positive and healthy. Instead of this misleading separation, we should rather focus on a product's use scenario. In some scenarios the use of chemicals in a product might be completely harmless and even useful, whereas in other use cases, it might cause harm to us and the environment. This issue can be resolved when we start thinking about a product's use scenario from the very beginning: when we design a product. Thus, we need to rethink the way we design our products and the materials we choose to use.

However, when we talk about product design, material health is not the only issue. We live in a world with scarce resources and our current way of production and consumption is not at all sustainable: we take resources, make a product and after its usage, the product or parts of it become waste. In the case of plastic packaging materials, 44% of them go into thermal recovery instead of re-using the processed resources (Umweltbundesamt, 2019). And even the packaging materials that go into recycling lose quality during the recycling process due to their linear design. By doing this, we are wasting valuable finite resources and are at the same time producing a massive amount of waste. Thus, with this linear way of production we are creating damage to ourselves and the environment. Instead, we need to start thinking in a circular way (Ellen MacArthur Foundation, 2022).

A new product design with Cradle to Cradle

Cradle to Cradle design combines circularity and material health. Cradle to Cradle (C2C) aims for a consistent circular economy which, in contrast to other concepts, already begins with design and material selection, and which regards humans as potential beneficiaries. In a C2C world, all resources circulate in biological or technical spheres. Materials from the biosphere are returned to the natural cycle, while materials from the technosphere can be continuously reused - making the concept of waste obsolete. Instead of consuming finite resources, we use them for their defined use scenario. In this way, they can become nutrients for new products again and again. The prerequisite for this is that products are developed for cycles right from the start: Suitable for a specific use scenario, beneficial within their specific usage scenario for people and nature, and recyclable without loss of quality (Cradle to Cradle NGO, 2022).

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Material health and positive ingredients

In order to develop a better understanding of the C2C design concept in the context of chemistry, we need to take a closer look at the concepts of material health and the use scenario. Starting with a product's design is crucial when we want to develop truly circular products. During this design process we have to rethink the way we choose the materials and ingredients. A C2C product must always be designed for its defined use scenario. When it is inevitable that parts of the product end up in the environment during or after its usage, these parts have to be designed for the biosphere and be, for example, biodegradable. This is relevant for any product with abrasion such as tires or textiles. Harmful chemicals or other materials that cause damage to our health or harm the environment must not be part of these products. When a product's parts do not end up in the environment, it must be designed for the technical cycles in the technosphere. To do so, the product must be built in such a way that it can be completely dismantled without leaving any residue, and every material can be recycled by type. In this way, we are able to design beneficial and circular products that provide benefits for us and the environment, instead of harming it (Cradle to Cradle NGO, 2022).

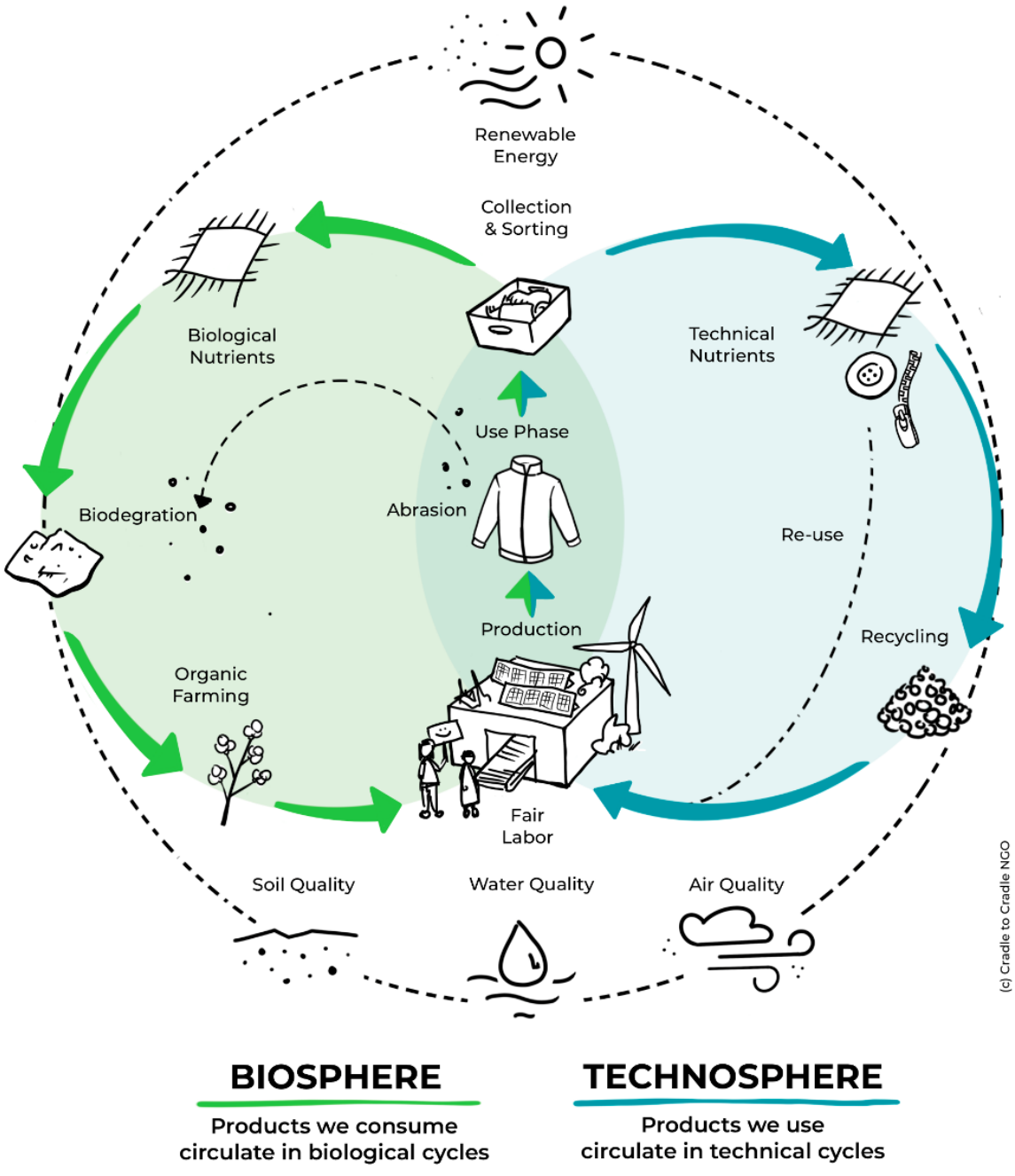

Figure 1 Biosphere and technosphere (Cradle to Cradle NGO).

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After defining the use scenario, we need to choose the appropriate materials and ingredients for the product. Right now, we often try to exclude harmful chemicals and cover our products with long lists of "free of's": free of microplastics, free of chemicals, free of aluminum salts. The problem with this approach is that excluding one ingredient does not mean that the rest of the product is harmless. In the 1990s, asbestos was used in brake pads for cars, but was then found out to be carcinogenic. Therefore, it was banned and a substitute, antimony sulfides, was used instead. However, later on, antimony sulfides were found out to be carcinogenic as well (von Uexküll et al., 2005). This shows that just by declaring a product free of something does not automatically mean that the product is beneficial or even harmless. A way to manage the process of deciding which materials should or should not be used are lists of banned substances, such as used by the Products Innovation Institute (Cradle to Cradle Products Innovations Institute, 2022). In their process of certifying C2C products, they combine lists of banned substances with lists of positively defined ingredients. Instead of only banning harmful materials, the products contain defined materials which are harmless or even beneficial for us and the environment. This goes along with the C2C school of thought: doing less bad is not enough, we need to be beneficial instead and create added value.

Why we need C2C in the chemical industry

The chemical industry is the basis and an imperative first step of production for a lot of other industries. Many products are dependent on materials produced by the chemical industry: colors for the textile industry, adhesives and sealants for building products or the automotive industry, synthetic materials for all kinds of plastic products, just to name a few (Accenture, 2017). If we want to achieve a circular economy starting by design, it is crucial that we start with the chemical industry. By doing this, we can set the course for all other industries. However, this is not only a nice-to-have for the chemical industry to become a little bit greener. Scarce resources and an unstable geo-political situation make the goal of a circular economy, based on the C2C principles, ecologically and economically necessary.

Implementing C2C in the chemical industry

But how can companies within the chemical industry start implementing circular business models and include C2C principles in their strategies? The starting point of a company's strategy needs to be a product's design. Trying to put an already existing product into a circular economy, is not going to solve our problems in the long-term. Instead, a product needs to be designed according to C2C principles right from the beginning, so it can truly be a part of a circular business model. To do so, companies need to invest into research and development to find circular alternatives for their materials. Process chemicals for example would be a good starting point for the chemical industry since they are used across industries and often responsible for water pollution during production. Additionally, cooperation is key for achieving a real circular economy. When companies work together with their customers and suppliers along the complete supply chain there is more potential for innovation and new ideas to rethink products in a circular way. Besides, the chemical industry needs to be open to different types of technology and materials. Just to name one example from the plastics industry, agricultural residues can be used for plastic alternatives (Traceless, 2022).

However, when companies within the chemical industry want to implement circular business models, they are facing barriers and challenges. Research and development of innovative materials and circular alternatives costs money which make some companies reluctant to invest in C2C solutions. In the long term, however, it pays off for companies to make these investments, both ecologically and economically.

Investment barriers are not the only challenges companies face when implementing C2C solutions and business models. Legal and political frameworks that encourage actions that are diametrically opposed to a circular economy pose another challenge on our way to a circular economy following C2C principles. When we take the plastics industry as an example again, it becomes obvious how indirect subsidies incentivize behavior which supports a linear way of production. As long as it is still cheaper to produce virgin plastic from crude oil in Germany, since it is exempt from energy tax, there is no incentive for the chemical industry to invest in plastics that are easy to recycle - regardless of the material (Wider Sense & Röchling Stiftung, 2020).

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Thus, it does not only need action from companies within the chemical industry, but also political action and the abolishment of subsidies that lead us in the wrong direction to achieve a circular economy according to C2C.

A circular use of carbon and phosphorus

However, Cradle to Cradle is not only a solution for circular and beneficial products but can also be applied to chemical elements such as carbon or phosphorus. Carbon is a good example of a resource we massively mismanage. In the form of CO2 in very high concentrations in our atmosphere, carbon is harmful and is accelerating the greenhouse gas effect. However, the goal of reducing CO2 emissions in order to fight climate change can only be an intermediate step. In the long term, we must see carbon - the basis of organic chemistry - for what it is: an important raw material that must be managed in cycles. Today, we extract oil from the earth, produce products from it that end up as waste, or burn it directly. In this way, too much carbon ends up in the atmosphere, where it accelerates climate change. A linear process and poor carbon management

A good example for circular carbon management is agriculture and soil. Humification processes incorporate carbon into the soil over the long term, making it the most important carbon store ahead of forests and oceans. However, this carbon is released during intensive use by conventional agriculture. We need to implement regenerative agriculture instead, which builds up humus and captures carbon and is more productive. This is not only smart carbon management but is also necessary to feed an increasing world population (Umweltbundesamt, 2022).

In addition, we need to promote negative emissions technologies such as biocarbons which we can use to recover CO2 from the atmosphere and use it for example for agriculture or in the plastics industry (Carbonauten, 2022). To do this, we need a science-based carbon management strategy that encompasses all sectors of the economy. In all these technologies recyclability must play a central role. Recovery and industrial applications must only use renewable energy that is produced in facilities that are able to circulate in the technosphere. Otherwise, we are merely postponing our problems instead of addressing interrelated problems in the long term.

Another good example which shows the potential of a circular use of resources is phosphorus. Phosphate (PO4) is found in minerals and is extracted in mines. It is essential for us humans since we need phosphorus for the energy metabolism in our cells and it is literally part of our DNA. Additionally, phosphorus is in high demand in agriculture since it is an indispensable nutrient for growing crops. At the moment, Germany is importing all of its phosphorus demand (approx. 120,000 tons of phosphorus per year) (Umweltbundesamt, 2019). However, the peak phosphorus, meaning the point of time at which the supply of phosphorus can no longer meet the increased demand, is expected to be reached between the years 2051 and 2092 (Umweltbundesamt, 2018). Thus, we are in desperate need of circular solutions to meet our phosphorus demand. Luckily, phosphate can also be found in high concentrations in urine, so it can be recovered either directly from urine or from sewage sludge instead of being repeatedly imported. The recovery rate within this process is quite high, so an estimated amount of 50,000 tons of phosphorus per year can theoretically be recovered (Umweltbundesamt, 2018).

How C2C can transform our economy

Phosphorus is only one example which shows how circular solutions can, among other benefits, make us less dependent on resource imports. In our complex political order full of global uncertainties and sometimes unstable value chains, circularity can be a reliable pillar. This reliability is important for the industry, also the chemical industry, which is highly dependent on imports.

However, circularity on its own is not enough to really transform our economy. In order to achieve a fully functioning circular economy following the principles of Cradle to Cradle, we do not only need circular products but also circular business models and reversed logistics on a global scale. Having circular products which are designed for their specific use scenario is an important step, but we also need appropriate logistics to allow products to circulate and to ensure that we have all the resources we need at the right place at the right time.

With this demand, the chance for a number of new business models emerges. Product-as-a-service models are a useful addition to C2C products: the manufacturer or another agent in the supply chain takes back the product from the

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consumer after its usage and can use the valuable resources for new products. These new business models must be accompanied by digitization. With digital material passports we can track at any time where valuable resources are currently located and what their market value is.

The transformation of our economy is not only necessary from a resource and climate point of view, but it is also a declared political goal to tackle the great problems of our time as well as preparing the European industries for the future. With the European Green Deal and the Circular Economy Action Plan the European Commission has set clear targets for a circular transformation of our economy and society. Within the Green Deal it is for example stated that all packaging needs to be recyclable or reusable by 2030 (European Commission, 2019). We urgently need the chemical industry to reach this goal.

In addition to this political imperative, it is important that the (chemical) industry begins to understand that a circular economy represents a great opportunity for the economy to ensure future competitiveness and to reconcile economy and ecology. Cradle to Cradle provides the blueprint for this as a design and innovation approach.

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