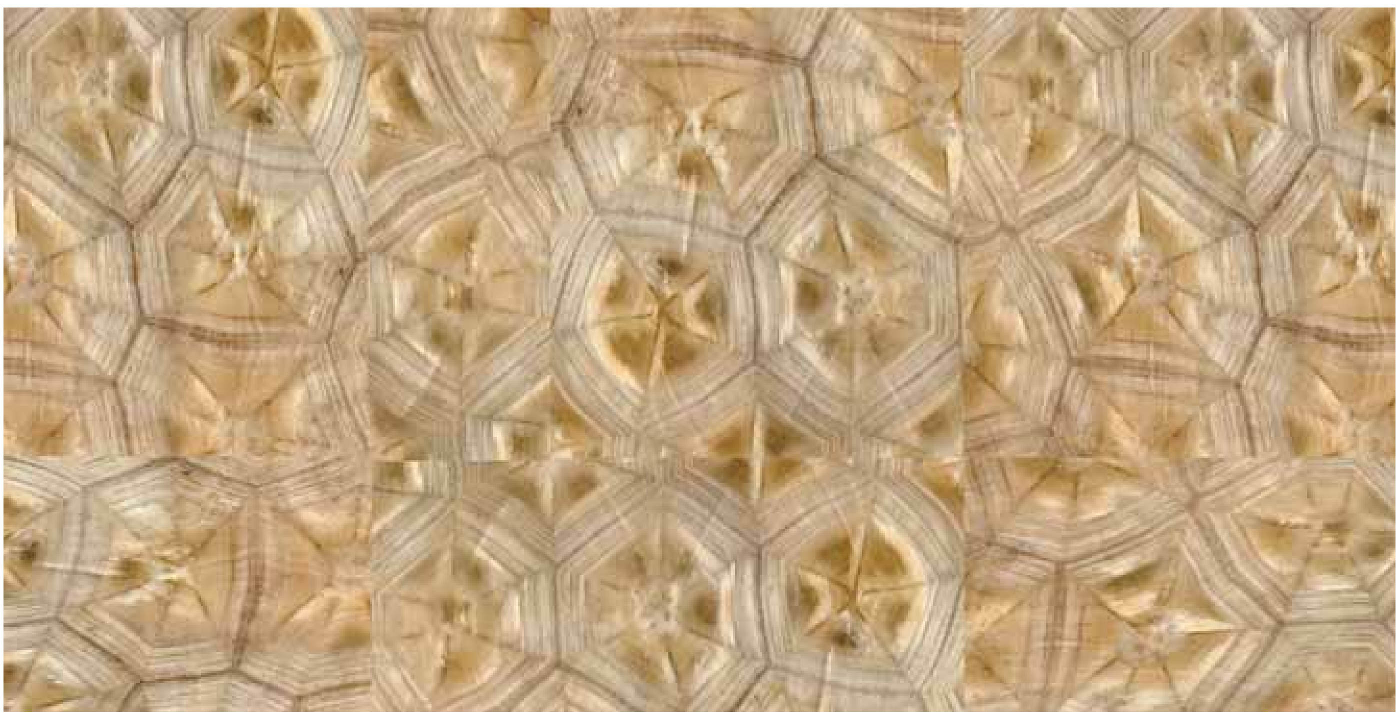
All About the Molecules: Sustainable Products Require Sustainable Materials

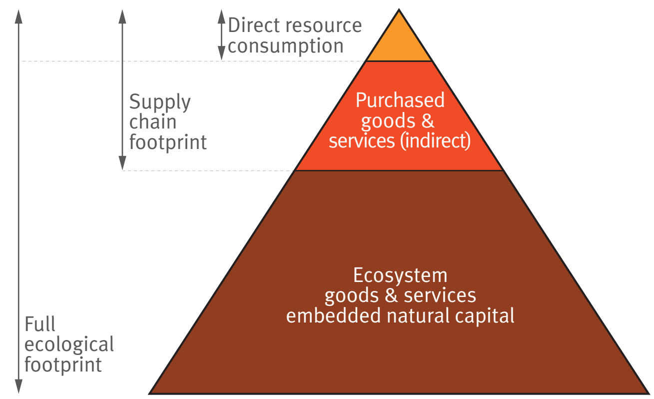


Improving an organization's sustainability requires ensuring that all the materials that go into making its products are safe for people and have the smallest possible impact on the environment.

Herman Miller has developed a rigorous protocol for evaluating the life-cycle impacts of every product it makes and every material that goes into making that product, right down to the molecule.

What We Know

In the last three decades of the twentieth century, the people of this planet used up one-third of the earth's natural resources (Hawken et al 1997). And these were the decades immediately following 1970, the year the United States established the first federal agency empowered by law to establish limits on industrial pollution: the Environmental Protection Agency (EPA). Although the agencies responsible for establishing environmental laws and the volume of regulations they impose increased dramatically during that time, most of the legislation focused on controlling pollutants at "the end of the pipe"—the final stages of manufacturing processes (Billatos and Basaly 1997).



The hidden mountain of resource consumption.

Ray Anderson, Interface CEO and author of *Mid-Course Correction*, has stated the issue clearly:

> "Industry moves, mines, extracts, shovels, burns, wastes, pumps and disposes of four million pounds of material in order to provide one average, middle-class American family their needs for a year. In order to reduce the amount of material we take and the waste we create, we first need to analyze all of our material flow—everything that comes in and goes out. Only then can we begin to address the task at hand." (Tokay et al. 2006)

One decade into the twenty-first century, however, we find that addressing the task at hand is very much behind schedule. Global levels of energy and material use continue to rise at a rate that exceeds what nature can supply. We are now spending what ecologists call our "natural capital"—the capacity of our planet's ecosystems to sustain life and absorb waste (Fiksel 2009).

Comprehending the scope of the problem and working toward a solution requires understanding the hidden flow of resources that go into the products we make and consume. The things themselves—the potato chips we eat, the bowl we serve them in—represent only the tip of the iceberg, around 5 percent of the raw materials that were used to make and transport them. The rest is invisible—to us—released into the environment in the form of wastewater, landfill trash, and airborne emissions like carbon dioxide (Fiksel 2009).

Clearly, true sustainability calls for more than limiting pollution and promoting recycling. It requires industrial systems that create more value with fewer resources at every link in the supply chain, from raw material extraction to product packaging and distribution (McDonough and Braungart 2002).

As Ray Anderson puts it, "… each of us is his supply chain. We are the sum total of everything that we consume. Our footprint is everybody else's footprint if they're in our supply chain" (Gordon 2008).

Therefore

Designing and making sustainable products requires a thorough knowledge of the materials that go into those products. We need to think about every material in every product from a life-cycle perspective, from raw material extraction to what happens at the end of a product's useful life. This means knowing every material's chemical composition and toxicity level, the source of the material (for example, Is it recycled or bio-based content?), how much energy is used to make it, and how hard it will be to return it to a useful state.

Design Problem

Develop a sustainability protocol that measures the environmental impacts of materials and can be integrated into a holistic approach to product design that evaluates and balances environmental criteria along with performance, cost, and aesthetic criteria.

Design Solution

In 1991, Herman Miller's Environmental Health and Safety group drafted its first "Design for Environment" (DfE) guidelines, to help product designers and engineers make environmentally intelligent decisions when choosing materials and manufacturing processes during design and development. As the group members began gathering information they realized that, while they were well informed about a given material's performance, they had little knowledge about its chemical composition and related environmental impacts (McDonough 2002).

After evaluating a number of existing environmental protocols, the team decided to partner with McDonough Braungart Design Chemistry (MBDC) to develop a cradle-to-cradle (C2C) protocol for selecting materials that could be integrated into Herman Miller's design and development process. Together they built an assessment tool that analyzes materials for their human health and ecological effects, recyclability, use of recycled content and renewable resources, and potential for product design for disassembly (McDonough 2002).

Since 2001, the DfE team has been working with suppliers to gather information about the chemical makeup of every material that goes into Herman Miller products. In some cases, this might involve tracking a material back through four or five tiers of suppliers: the company that manufactures a chair component, the company that manufactures the plastic for that chair component, the companies that make the colorants for the plastic, and finally, the companies that make the pigments for the colorants. Every ingredient of every material, down to those that make up as little as 0.01 percent (by weight) of both the material and the final product, is identified. Findings from these assessments are entered into Herman Miller's ever-evolving materials data base and sent to MBDC for assessment of potential environmental or health hazards posed by the chemicals used to manufacture the material. Table 1 shows the human and ecological health criteria MBDC uses in this evaluation (McDonough et al., 2003).

If a material is found to contain a chemical that MBDC classifies as potentially hazardous, Herman Miller will work with the material's supplier to make changes that eliminate the hazard or to develop or find an alternative material. This is an ongoing process as the company looks at products that were designed before the sustainability protocol was in place. "We're looking at PVC alternatives, we're trying to get formaldehyde out of our particle board, we are looking at fiber glass replacements," says Scott Charon, advance materials manager at Herman Miller. "By the year 2020 we want to be a totally sustainable company," with all products made from materials based on non-hazardous chemical inputs (Metropolis 2007).

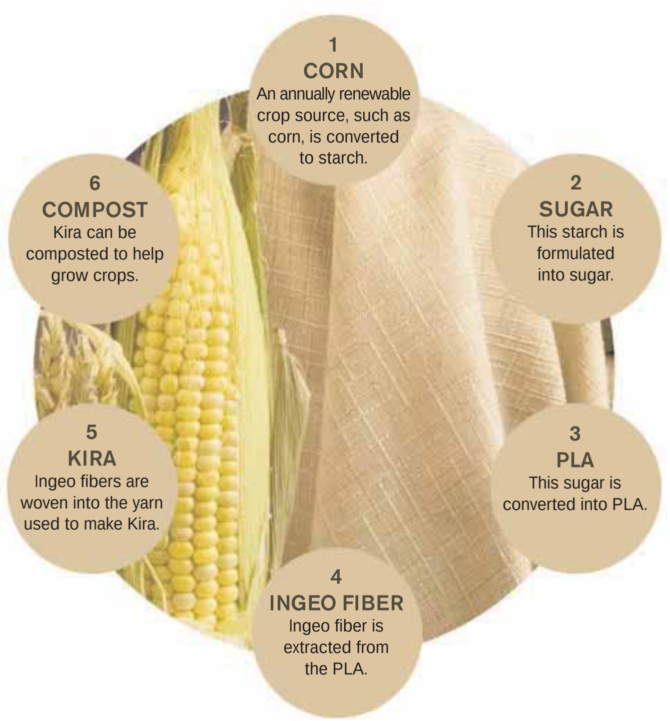
Human Health Criteria	Ecological Health Criteria
· Carcinogenicity	· Algae toxicity
· Teratogenicity	· Bioaccumulation
· Reproductive toxicity	· Climatic relevance
· Mutagenicity	· Content of halogenated organic compounds
· Endocrine disruption	· Daphnia toxicity
· Acute toxicity	· Fish toxicity
· Chronic toxicity	· Heavy metal content
· Irritation of skin/mucous	· Persistence/biodegradation membranes
· Sensitization	· Other (water danger list, toxicity to soil organisms, etc.)
· Other relevant data (e.g., skin penetration potential, flammability, etc.)	

Table 1

In addition to screening for problematic chemicals, the materials data base allows the DfE team to assess the life-cycle impact of its products, tracking the volume and content of the raw materials that go into a product and evaluating their potential for reuse at the end of the product's useful life. Ultimately, the goal for C2C design is "closing the loop"—creating products made entirely of materials that can either be recycled into new products or returned to nature through composting.

Closed-loop materials are homogenous—backings, coatings, and over moldings that mix dissimilar materials can be difficult or impossible to reuse in ways that recapture their original value. A closed-loop plastic, for example, would be capable of being depolymerized ("unzipping" a polymer into its basic building blocks) to make an equally valuable material.

Bio-based materials that are made of sustainably harvested renewable sources (such as wool or cotton) and that can eventually returned to the natural cycle are another good fit with C2C design. When Nature Works (formerly Cargill Dow) introduced a new high-performance polymer made of corn sugar in 2004, Herman Miller partnered with True Textiles (formerly Interface Fabrics) to use it to create a new fabric line that can be composted at the end of its life. No petrochemicals are used in its fiber construction and the dyes used to color the fabric contain no heavy metals, so the material can be safely and easily returned to the earth. In a commercial composter, the fabric breaks down completely in just three days, becoming compost that can be used to fertilize future corn crops.



Evaluating the "embodied energy" of a material—how much energy was used to extract, transport, and transform it into its current state—provides yet another piece of crucial information about its environmental impact. The DfE team gathers information on carbon emissions associated with the energy use required for raw-material extraction, assembly, delivery, and end-of-life disposal to determine a material's carbon footprint. Setting benchmarks for the level of embodied energy in our products ensures that materials selection takes into account this energy use and carbon emissions.

Another aspect of embodied energy—the energy used to "transform," or manufacture, materials into a product—is related to an issue of growing concern, namely, the depletion of non-renewable resources, such as coal and oil. As evidence grows that fossil fuels will be depleted, perhaps in this century, the focus on renewable energy sources has intensified. Indeed, recently Herman Miller announced that it is using 100 percent renewable electrical energy for its worldwide operations.

Applying the sustainability protocol in the design of new products or the redesign of existing ones is complex. Inevitably there are trade-offs in selecting the best material for a specific use. A material may be free of toxins but have a large carbon footprint, for example. And of course the cost, appearance, and performance level of a material must always be taken into account by a company with the goal of providing products that are durable, attractive, and cost-effective—as well as environmentally friendly.

HOW IT WORKS

Since 2001, all new Herman Miller products have been developed using the C2C protocol, and the effects of the new material selection criteria on product design have been far-reaching. The first product to be designed completely under C2C, the Mirra® chair, launched an effort to find an alternative to polyvinyl chloride (PVC), a standard furniture industry material that MBDC disallows because of toxins that are released during its manufacture and when it is burned. A thermoplastic elastomer was found to replace the PVC material used for Mirra's arm pad. Since that breakthrough, the arm pads of the Aeron® chair have been re-engineered to utilize a PVC-free self-skinning urethane foam (replacing PVC stapled to foam), and PVC-free polypropylene edge-banding has been developed for use on all rectangular work surfaces. And My Studio Environments™ has a PVC-free electrical system that is standard..

Hard-won solutions like these, incorporated into Herman Miller's materials database, help to inform future designs and streamline the process of material selection. With the C2C protocol narrowing the field of materials to choose from, the DfE team focuses more on how to make the available materials work. The result is often innovation.

For example, during the development of the Mirra chair, C2C compliance forced the team to look for an alternative for a part (the structure that supports the back of the chair) that had originally been designed in metal with a plastic overmolding—a combination of dissimilar materials that would be hard to break down for recycling.

After more materials research and several design iterations, the team developed a part made entirely of a recyclable material that not only met C2C criteria, but was less expensive than the original design.

Most important, by embedding a sustainability protocol into its materials-selection process, Herman Miller is able to influence environmentally friendly choices and processes all along its supply and distribution chains. Influence has been most successful when

Herman Miller partners with its suppliers, working together to make a difference.

In 2004, Herman Miller launched "Perfect Vision Program: 2020," an ambitious sustainability initiative that includes the goal of having 100 percent of its sales come from products that comply with DfE's C2C standards, ensuring that every part of every product is made of the safest and most environmentally friendly materials—right down to the molecule.

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