Thomas Schröpfer

Material Design

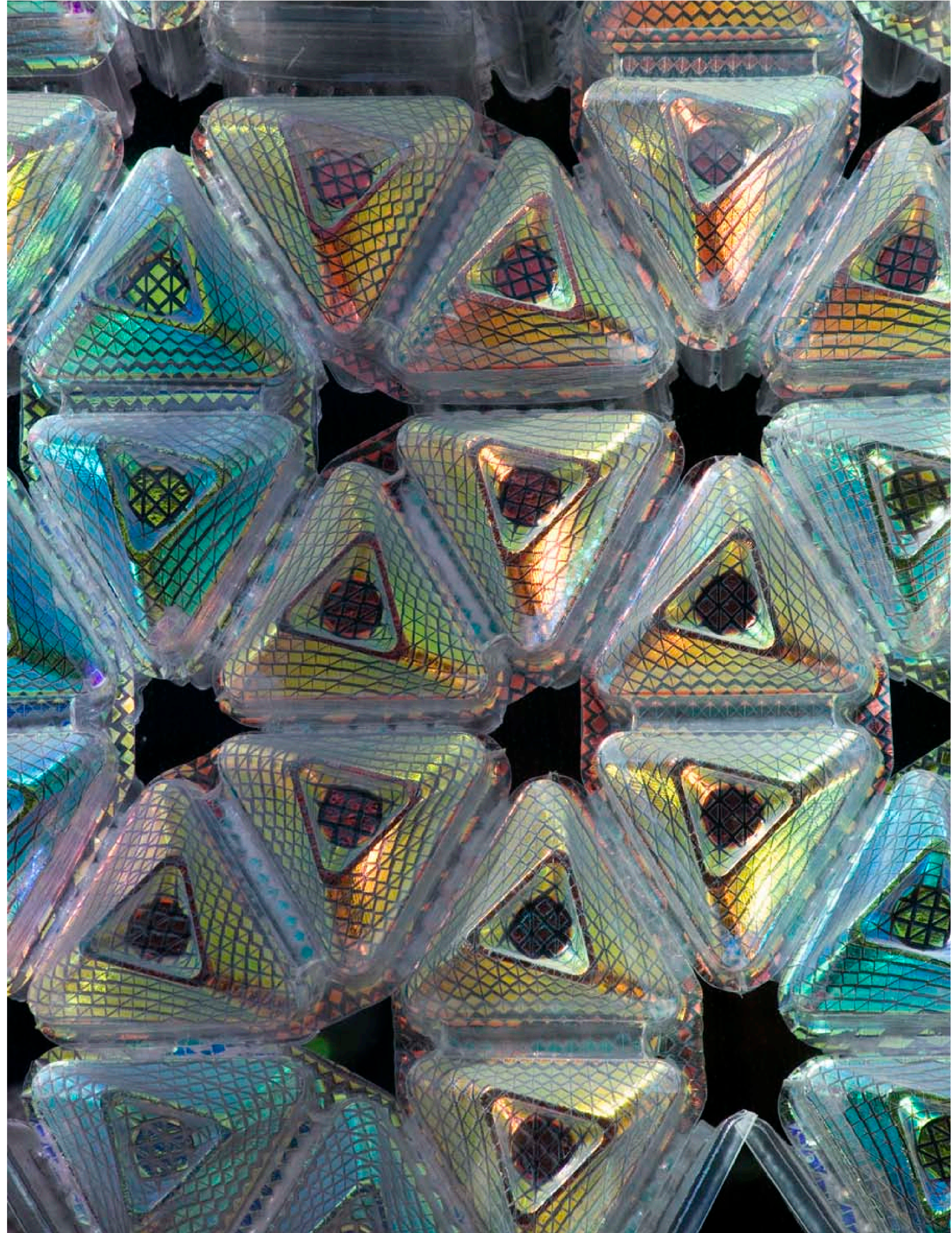
Informing Architecture by Materiality

BIRKHÄUSER

Encoding
Digital & Analogue Taxonavigation

Liat Margolis

Lee-Su Huang and Gregory Thomas Spaw, Osnap!, installation at the Harvard University Graduate School of Design, Cambridge, Massachusetts, USA, 2009, vacuformed PETG plastic laminated with laser-etched dichroic film (3M's Radiant Light Film), detail.



Immersed in a surge of hyper-materialism, we find ourselves vacillating between our commitments to ultra-performance and environmental responsibility, and our fascinations with irreverent material mutations, outrageous morphologies, and sensorial maximalism of luxury and effect. Whichever fixation prevails, new materials – from self-cleaning glass, electroluminescent films, photocatalytic, ductile, self-repairing, and porous cements, to ultra-insulating foamed aluminum, and super-absorbent polymers that can rapidly soak up toxic spills – have launched us into a vortex of "hyperchoice" [1] and infinite material dialogues.

Inventions on the molecular level of material composition on one hand, and the influx of technologies that allow new aesthetic and performance possibilities on the other, have positioned contemporary materials in a perpetual future tense. This gluttony of material options and cravings for novelty have given rise to the contemporary models of material collections and classification systems. And while these new mechanisms of material research are largely contingent on technological prowess, they are also profoundly invested in the procedure of technological knowledge transfer – a cross-disciplinary exchange of often unrelated fields. Both those tenets are the basis for the content of material collections; and insist on new delineations and new ways of interrelating data in order to further dissolve the limitations created by conventional disciplinary boundaries.

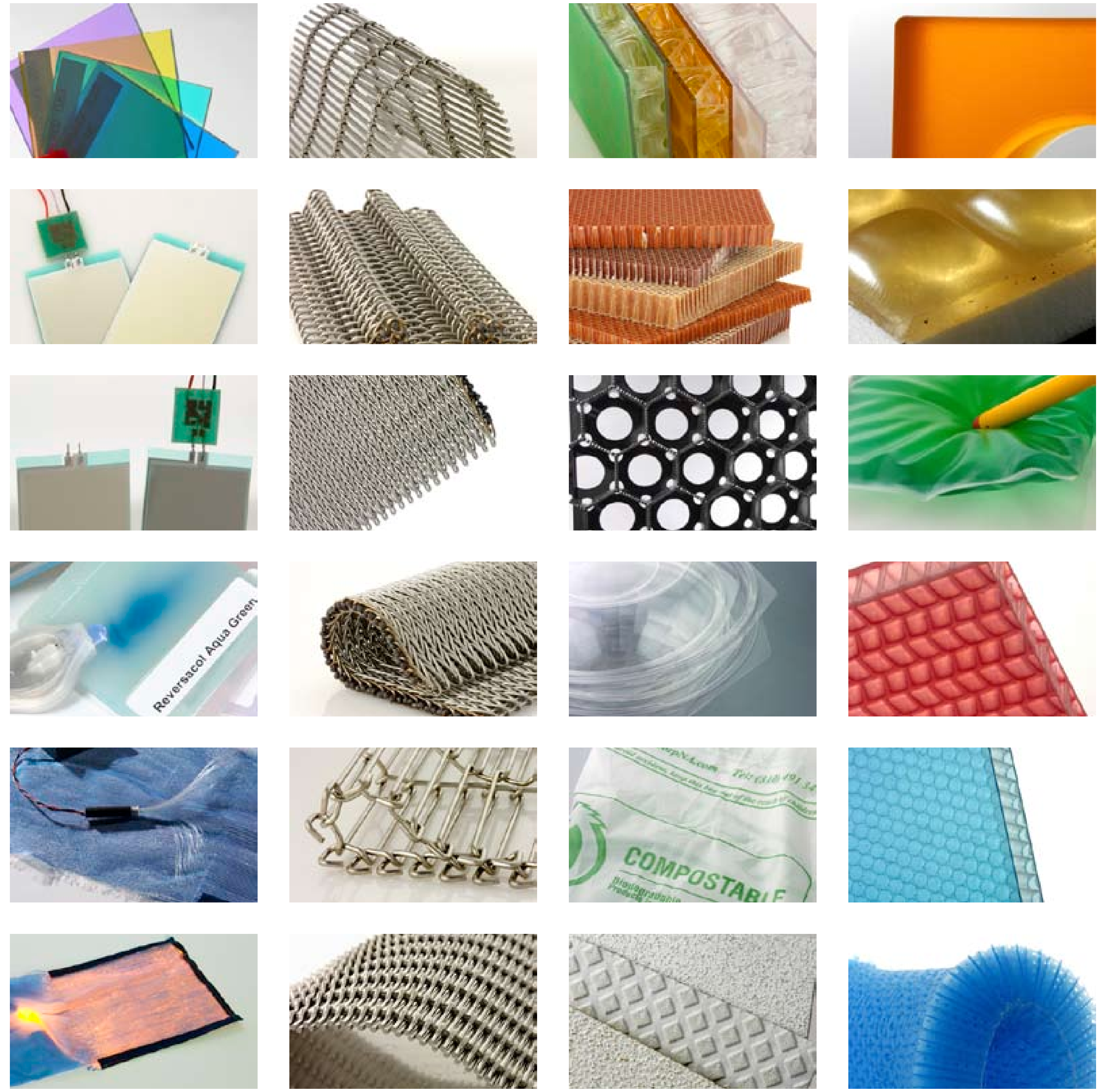
The profusion of materials today and their frequent adaptation from one industry to another exhibit a certain resistance to architectural classification systems, such as the Construction Specification Institute (CSI), whose underlying code is dominated by predetermined architectural applications. If design innovation is reliant in part on hyperchoice and technology transfer, then material classification necessitates a flexible indexing structure that would link their intrinsic properties to a diversity of applications and hence transcend the "classificatory pigeonholes"[2] of architectural conventions. How do we organize a unified physical archive of contemporary material specimens that may originate in fashion, civil engineering, automotive and biomedical design? How do we inter-relate taxonomy distinct to metallurgy, polymer science, and botany, such that it can generate cross-pollination among disciplines? And what is the relevance of material classification to the process of design as well as pedagogy?

Newness

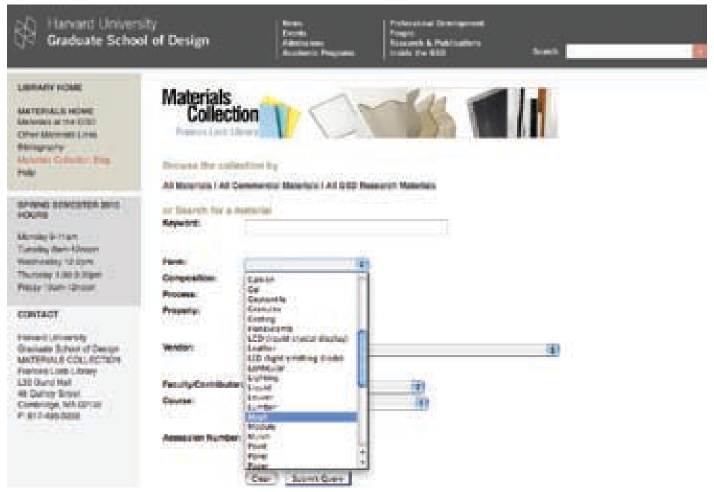
An illustrated lexicon of current praxis, *The Metapolis Dictionary of Advanced Architecture* (2003), poses that in the context of information technology, which requires and facilitates new approaches to the conception of architecture and cities, architects cannot rely solely on the professional standardized conventions, but rather on innovation in design and the application of new techniques and materials.[3] The authors call for a relational and non-linear format for their dictionary in order to interlink distinct conceptual frameworks – "a matrix of terms, a mesh of codes" that is open to cross-referencing and allows for a shift in architectural culture.[4] They state: "If, in fact, the emergence of the new is almost invariably a cause of uncertainty (precisely because we do not know how to label it, and thus the difficulty of isolating the signs that are its expression and identifying the relationships of those signs with the existing ones) this necessary conceptual reactivation (and redefinition) of language is indispensable for a prospective action that does not stop at establishing a collection of fixed (and all encompassing) labels."[5] For instance, the *Metapolis Dictionary* permanently encodes our contemporary association between the term "blur" and the Diller and Scofidio Blur Building at the 2002 Swiss Expo in Yverdon.

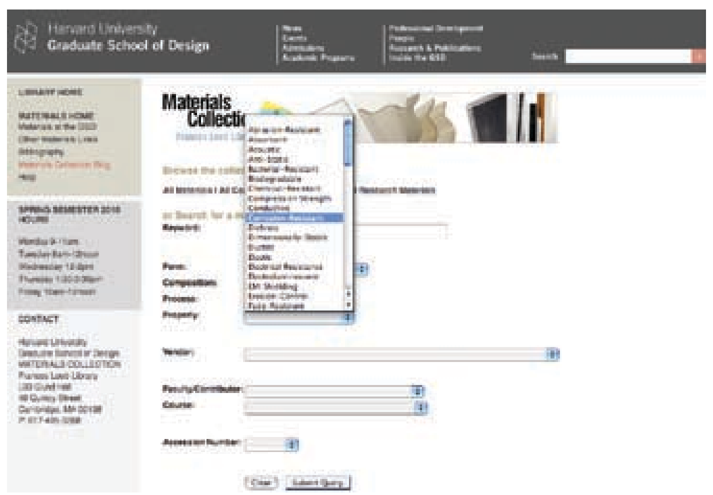
Taxonavigation in design and architecture, much like the contemporary preoccupation with tagging, labeling, blogging, and wikiing has become integral to praxis and pedagogy. More recently, founders of Paris-based material library matériO, Daniel Kula and Élodie Ternaux, continue to acknowledge the pervasive interest in a synthetic and relational data structure, and more specifically expose a primary quandary (as well as the primary motivation to their own work) concerning the polysemy, or lexical ambiguity of material nomenclature. In their book *Materiology* (2008) they eagerly admit: "One of the main difficulties in understanding the concept of matter is

Harvard University Graduate School of Design,
Materials Collection, material samples.



Harvard University Graduate School of Design, Materials Collection online database search options: by Form (Mesh) and by Properties (Corrosion-Resistant), screenshots.



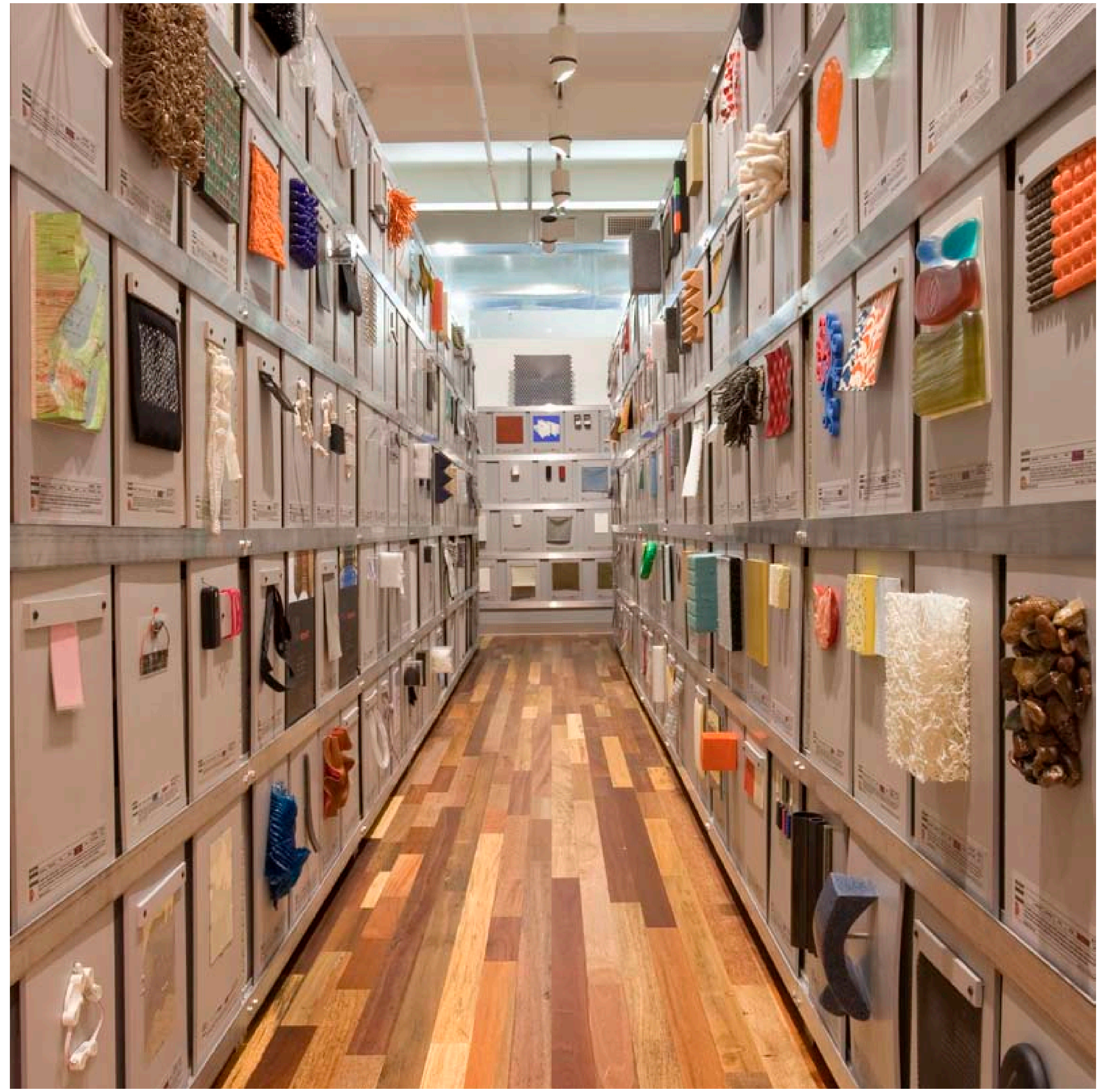


that it requires many tools which do not all employ the same level of language and approach… Matter can be experienced through sensory perception, technical description, scientific theory, or a philosophical approach – so many possibilities which inextricably overlap elements of different definition."[6]

In the context of this book's title, *Material Design*, "material" is similarly predicated on the notion that it is simultaneously matter – an alchemy of the periodical table; and meaning – that which accrues behavioral descriptors according to their ever-changing empirical or theoretical contexts. Therefore, "materiality" is not only synonymous with structural and aesthetic categories, but is also aligned with evolving theoretical positions on the perceived or potential role of materials in contemporary culture. Whether sensorial, ideological (e.g. sustainability), structural, performative (e.g. bioremediation, self-repair), economically viable, new or outmoded, material meaning is mutable. Consequently, the format of the contemporary material collections has been structured to facilitate ongoing feedback loops between the inauguration of new materials and the redefinition of design forms, processes, and culture.

This techno-cultural feedback loop can be identified, for instance, in Kula and Ternaux's description of the concurrent development of polymeric elasticity alongside the fascination with softness: "Often defined as an opposite, being soft ('not hard') has become a sought-after quality. Soft-to-the-touch keyboards and other ergonomically designed controls, shoes, and even automotive interiors, use flexible and casual shapes, and reactive materials such as 'memory' foam or medical gel… An intermediary state *par excellence*, neither solid, nor liquid, 'soft' has never deserved much scientific attention before now. Scientists were always far too busy studying those states of matter deemed 'fundamentally noble'. New areas of exploration are now tentatively opening up, into this transition between phases, a more adapted-adaptive response. Is this perhaps a fourth state of matter? A highly ambiguous state, it provokes attraction and repulsion, sparks irresponsible tactile temptation and hides unexpected depths. Nasty or nice? Softness fascinates us because it is reminiscent of life".[7]

Material ConneXion, New York, New York, USA, material archives and samples.



Material ConneXion, Cologne, Germany, material archives and samples.

iMatter, Holon, Israel, material archives and samples.

Implicit then in the advent of technological agility are contemporary policies and cultural intrigues such as softness, transparency, ultra-lightweight, optical elusiveness, and biodegradability, to name a few. Although scientists and engineers insist on the objectivity of material facts, it is evident that the reverse holds true; the mutability of material meaning and relevance lies in recontextualization.[8] With the widespread topic of sustainability, for instance, environmental testing and performance specifications have become more available, which in turn have made our environmental eloquence in design more explicit. Furthermore, it was the urgency of environmental concerns and policies in the last 20 years that has driven giant plastic manufacturers to materialize the polymerization of starch from beets and corn and the manufacturing of biodegradable plastics. Once we enable a deviation from architectural classifications, new considerations arise, new testing parameters and qualitative performances are identified, and design language expands. Recontextualization is the material collector's recipe to incite innovation.

Genre: Unclassifiable

The CSI MasterFormat has prevailed as the standard classification and specification system for over 50 years in the USA. It organizes materials hierarchically, according to firstly, generic materials groupings such as paint, laminate, and concrete, and secondly, according to components or systems. According to Michelle Addington and Daniel Schodek these categories are not material- or performance-specific – such that the category of windows, for instance, includes multiple materials (e.g. wood, vinyl, aluminum, or steel) – thus giving primacy to applications and common uses. Properties are solely considered in the context of codes and requirements for preconceived applications. For example, wood is discussed only according to its suitability for load-bearing roof structures or flooring; doors are organized according to their suitability for security, fire protection, egress, or by the distinction between commercial or residential use.[9]

The hierarchical and linear information structure limits the possibility of unexpected solutions. For instance, woven stainless steel conveyor belts would typically be categorized under Conveying Equipment; a category one may not think to explore for the purpose of building facades, doors, or wall structures. And yet, the widespread use of metal meshes that originate in the conveyor belt industry have enabled many important architectural projects, including those of Dominique Perrault at the Bibliothèque Nationale de France in Paris and the Olympic Velodrome and Swimming Pool in Berlin, as well as the work of Studio Morsa at the Comme des Garçons shop in New York. Instead, the material collection system lists the conveyor belts according to multiple searchable attributes including: material content (metal), form/structure (mesh), fabrication process (woven), and properties (flexible, corrosion-resistant).

Addington and Schodek assert that conventional architectural codes are not intended to engender innovation. Rather, they are practical templates for communication between architects, contractors, fabricators, and suppliers.[10] Hence materials are relegated strictly to specifications at the end of the design process rather than utilizing material investigations as an iterative and generative process to design development. The peripheral consequences of a specification-driven system generally are the exclusion of new and unusual material technologies due to an emphasis on liability and known entities. Addington and Schodek state: "For many uses, codes and standards explicitly or implicitly identify acceptable materials, leaving the architect only to select between brands."[11]

The departure from conventional classification systems began with Material ConneXion Inc. (MC), which in 1996 established an unprecedented material library and consulting service, after which a number of commercial and academic institutions followed suit to both leverage and alleviate the urgent demand for the latest developments in materials (ills. pp. 153, 154, 170). The context to MC was Ezio Manzini's 1986 book *The Material of Invention*, as well as two seminal exhibitions – "Mondo Materialis," organized by MC's founder George Beylerian for the Steelcase Design Partnership in 1990,[12] and "Mutant Materials," curated by MoMA's Paula Antonelli in 1994.

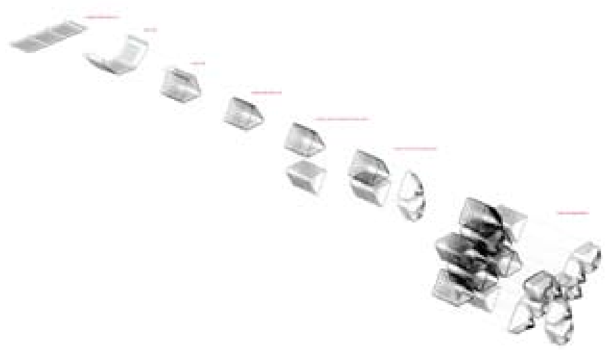
Both exhibitions set forth an unprecedented emphasis to materials and their mutable truths. *Mutant Materials*[13] in particular was first to curate projects according to material composition (e.g. glass, plastic, ceramic) and performance (e.g. photochromism, elasticity, shape-memory). For the first time featured on pedestals were items such as 3M Privacy Film (liquid crystal film) laminated onto glass, manufactured by Vitracon in 1991 and designed to change its opacity from transparent to opaque upon being exposed to an electric field. Also featured was "Mobil" Container Systems, designed by Antonio Citterio for Kartell S.p.a. in 1993, and made of thermoplastic polymer that was fabricated to look like sand-blasted glass. The focus of the exhibit was on the designers' material use as much as on their "material misuse."[14] And although the show included everything from chairs to lighting to medical devices, the unifying sensorial tactility gave proof to the time's technological material triumphs.

Material Collections

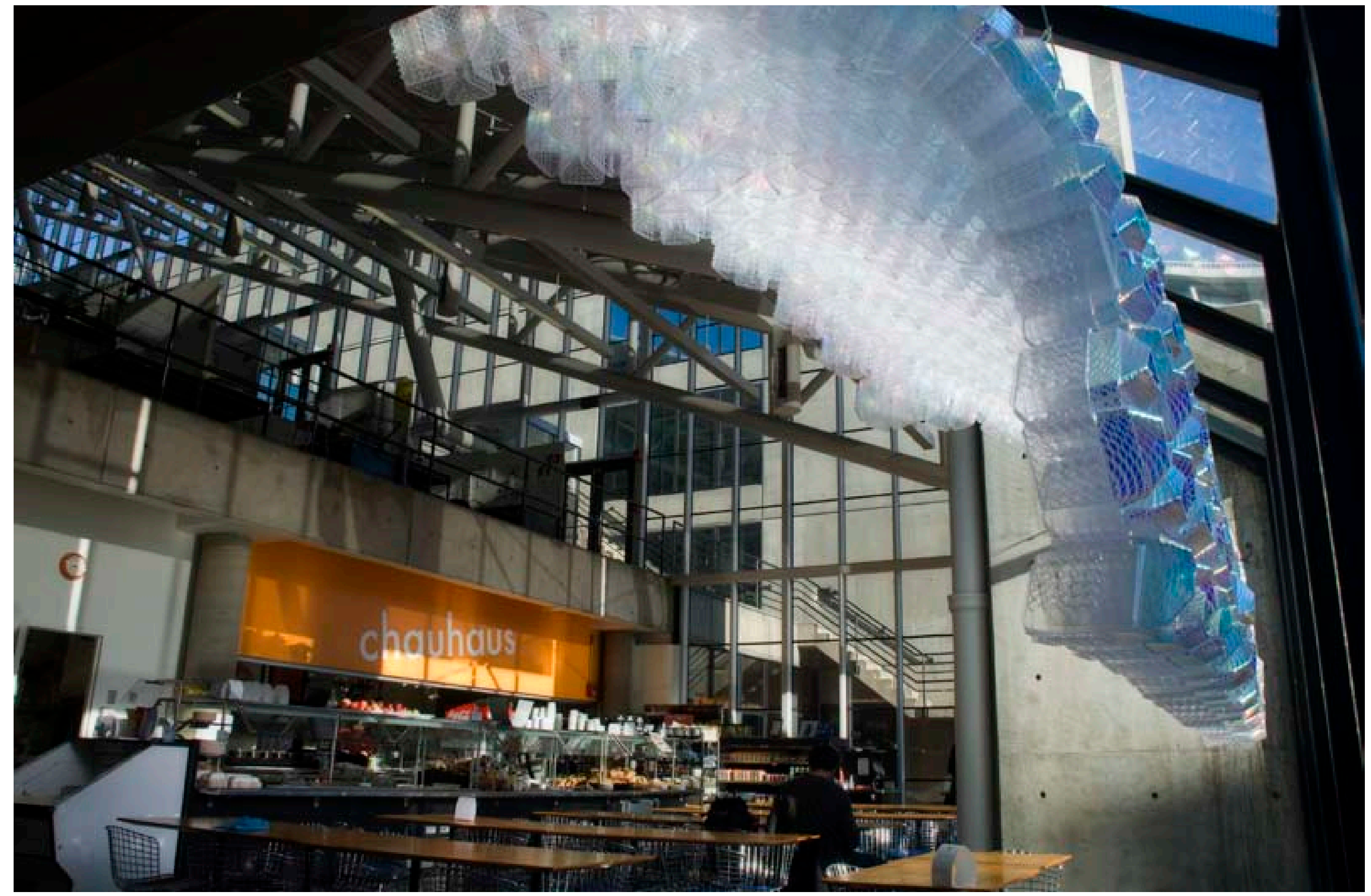
MC was the first attempt to break away from the standard CSI system and develop a new database model for material classification based in properties and processes. It positioned itself as the link between designers, material scientists, and the manufacturing industry, which then lacked a physical and digital forum in which to do so. The multi-disciplinary research platform was established intentionally to be relevant to many design fields ranging from architecture to fashion in order to promote a blurring of disciplinary boundaries. With a current collection of over 5,000 material samples, a gallery space, and a magazine called *Matter*, this modern-day *Wunderkammer*[15] has opened the floodgates for the cultural fetishism of material collection, and articulated the crossover of disciplines through a reconstituted classification system.

The curatorial aspect has been consistently rooted in the identification and acquisition of the techno-culturally "new and innovative." This premise consists of three main criteria: literally new; new to the design fields; and conceptually aligned with current thematic streams, such as the interest in cellular structures and biomorphic geometries as featured in the seminal publication *Emergence: Morphogenetic Design*

Lee-Su Huang and Gregory Thomas Spaw,
Osnap!, installation at the Harvard University
Graduate School of Design, Cambridge,
Massachusetts, USA, 2009,
assembly sequence.



Lee-Su Huang and Gregory Thomas Spaw,
Osnap!



Strategies,[16] or in *Praxis, Journal of Writing + Building* in the issue titled "Expanding Surface" about the works of Andrew Kudless of Matsys. In this context, MC typically identifies widespread or emerging dialogues in design and re-calibrates its acquisitions accordingly. In other cases, its content influences new explorations in design. For instance, cellular structures, ranging from honeycomb and multi-core panels to aluminum foam and reticulated polymer foams, have occupied the shelves of many collections since 1997. Inspired by such samples, both the material developers Panelite (whose work is described later on in this chapter) and OMA's material researcher Chris van Duijn explored a series of cellular wall structures based on the geometry of a sponge for flexible clothes display systems in the New York and Los Angeles Prada Stores.[17]

Another example for the departure from conventional material classification systems is the Materials Collection at Harvard University's Graduate School of Design (GSD) (ills. pp. 150-152, 162). Founded in 2003, it is largely based on the same approach. The principal difference to MC is its aim to curate materiality in conjunction with the pedagogy and current discourse at the GSD. Set forth is an objective to utilize material technology research as a forum for curricular developments, publications, conferences, seminars, and prototyping (ills. pp. 149, 156, 157, 160). Much like the Material ConneXion system, the Materials Collection's physical archive and online database are designed as a cross-referenced categorization system. Additionally, the research conducted within the school's design studios and seminars feeds back into the Collection, creating an institutional archive of material trends and critical thought.

Today, material collections can be found in many locations throughout the world: MC has locations in New York, Milan, Cologne, Bangkok, and Daegu. Since 2002 matériO has established locations in Paris, Antwerp, and Barcelona. Materia launched their material center in Holland; iMatter opened in 2007 in Holon, Israel (ill. p. 154); the Swiss equivalent Material Archiv was launched in 2008; all of these are based on the premise of providing a liaison between design, industry, and science through consulting services. Therefore, each physical location is often affiliated with other commercial or cultural associations to leverage local networks and catalyze economic and cultural development. Many of these membership-based organizations are also affiliated with academic institutions. Most offer academic membership packages, which grant access to the entire student body within an academic institution, and in some cases a custom selection of the physical library, according to the school's curricular focus, is duplicated and installed onsite. Some schools, such as the GSD, the University of Texas in Austin, and the Parsons School of Design, have established their own physical sample libraries and in some cases have also developed their own databases, independent of their memberships, with some of the above-mentioned services.

What is unique about the new models of material collections is that their subscribers come from different fields, which effectively produces a natural cross-pollination through their design requirements and field-specific terminologies. As the Material Research Director at Material ConneXion, I conducted research for BMW's automotive design team, who investigated textile-embedded sensor technologies and responsive textiles as an alternative solution for the metal car body. In the same period, I consulted for Target, who was developing a new line of electronics with Philips Electronics and Motorola Corporation; and for the cosmetics company AVEDA, who mandated environmentally responsible materials for their cosmetic product packaging. Two years later, Target launched their Iridescent Evolution using ChromaFlair, an iridescent coating that is widely used in the automotive industry; AVEDA introduced a new line of cosmetics utilizing a composite plastic that contains 70% agricultural byproducts such as coconut fibers and wheat husk.

Another important aspect to the collections is the physical material archive, whose format is designed to allow for material adjacencies that are at times completely unexpected. For instance, on the same shelf at Harvard's Materials Collection in the polymer section, one may find a View Control Film that was developed for automatic teller machines, and ethylene tetrafluoro-ethylene (ETFE) film that was originally designed as a release film for semiconductor and aerospace coatings. Using conventional cataloguing systems that are application-

based, those two films would never sit adjacent, or appear on the same database search results. In fact, those films may never even be part of a conventional architecture material library. However, both those films have been shifted from the periphery of architectural applications to the very center of inquiry in the last ten years. For example, View Control Film, which changes its transparency upon the viewer's angle, was used for the storefront window of Issey Miyake's Pleats Please boutique in SoHo, New York, designed by Toshiko Mori Architect in 1998. ETFE film is now legendary for its application in the 4,000 cushion panels (100,000 m² of Texlon® ETFE produced by Vector-Foiltec) on the 2008 Beijing Olympic Swimming Center ("Water Cube"), designed by PTW Architects and Arup. Compared to glass, ETFE is 1% the weight, transmits more light, is a better insulator, and costs 24 to 70% less to install.
It is also resilient (able to bear 400 times its own weight, with an estimated 50-year lifespan), recyclable, and, like Teflon®, it is non-stick, non-staining and therefore requires no cleaning. A search in a conventional architectural material database for cladding materials would result in the ubiquitous glass, wood, metal, while a chance encounter (via the physical or digital archives) with a film, such as photovoltaic, photochromic, light interference, view control, or electroluminescent films, may revolutionize the meaning of the basic categories of how we make sense of materiality.

Analogue

Three key attributes define the physical material collection. The first is its immersive tangibility; its visual and tactile actuality. A common critique, particularly by engineers is that the selection of materials is strictly based on sensorial characteristics.[18] I would argue, however, that sensorial immediacy, experimentation and testing, prototyping and juxtaposing palettes of materials are essential to the design process even if this reduces certain elements of utility or efficiency made possible with the CSI database. Similarly, analogue modeling is at times most effective for the development of a design idea, despite the accessibility of sophisticated parametric digital programs. For instance, the visual effect of a dichroic-coated glass – where the light spectrum is simultaneously transmitted and reflected – is much better understood when visually experienced, rather than strictly read as a text. Furthermore, one could even argue that if designers would encounter the term dichroic in the database they might possibly disregard it, because the term is unfamiliar. Conversely, the visual intrigue may pique designers' interest to further examine the benefits associated with dichroic glass and also to discover its prevalent use in projects by designers such as James Carpenter.

This leads to the second aspect of the material sample library, which lies in the concept of displaying materials out of their conventional context. This format allows the designer to decontextualize materials from their typical associations in order to derive new ideas from their physical attributes. For instance, originating in the aerospace industry, the super-insulating Aerogel technology is now frequently used for high-performance sportswear and architectural panels; gabion cages typically used to stabilize eroding slopes form the temperature- and light-regulating permeable *brise-soleil* walls of Herzog & de Meuron's Dominus Winery in Napa Valley, California; geotextiles and bioengineering are now commonly integral to greenroof structures, such as in the case of the California Academy of Sciences in San Francisco by Renzo Piano Building Workshop and SWA. In similar manner Kurt W. Forster writes about the work of Herzog & de Meuron: "The transcendent quality Herzog & de Meuron seek in materials must spring from within a project after those materials have been removed from where they normally occur or have been divested of the purpose for which they are customarily employed. Within the tight matrix of utility and convention, materials offer no resistance. Only when altered or removed from the field of conventional reference can materials assume a specifically architectural purpose. It is precisely, and solely, from the discrepancy between their familiar purpose and newly invented ones that materials acquire character."[19]

The evolution of the translucent honeycomb panels by Panelite is an outcome of decontextualization. While graduate students at Columbia University, company founders Emmanuelle Bourlier and Christian Mittman sought a translucent, structural yet ultra-lightweight panel material they could use as a pivoting wall for a residential pool house. At MC, they found honeycomb

Rem Koolhaas/OMA, Student Center at IIT,
Chicago, Illinois, USA,
Panelite honeycomb panels, 2003.

panels, which are typically used for the construction of the airplane wing. This composite honeycomb core interlayer, sandwiched between two metal sheets, answered their need for a high-strength-to-weight ratio, but did not comply with their vision of translucency. During the same search in the library, they also came across a translucent fiberglass panel and decided to "material design" their own panel by taking only the honeycomb core and developing a now patented adhesive technology to laminate translucent sheets. Shortly after, Panelite was formed not only as the manufacturer of honeycomb panels, but also as a material designer who works with architectural firms to research and develop new materials. For example, the honeycomb composites now clad the Student Center at the Illinois Institute of Technology by Rem Koolhaas/OMA (ills.).

The third assertion about material collections is that they should be driven and guided by the intellectual trajectories and experimental objectives of their subscribers, whether professional or pedagogical. Once again, it is crucial to distinguish material collections from specification systems, whose contents are based on industry advertisement, by their sheer autonomy to be shaped according to their distinct interests and cultural contexts, rather than by financial interdependence to industry. However, self-directing independence is not all that I refer to, but rather more importantly, the proficiency of the institution and its material curators' ability to evolve the content according to their dedicated identification of contemporaneous ideas and agenda. Perhaps not unlike the *Wunderkammer*, the frenzied and indiscriminate compilation of material specimens today necessitates a percipient curatorial process, whose expertise in discerning between the banal and the unusual to uncover today's "Age of Explorations" is on a par with with astute observations of trend-forecasting firms and design critics. At Material ConneXion, the curatorial method enlists a jury of various acclaimed designers each month to deliberate on the inclusion of recently acquired materials.
It is because the objects of fascination speak of meaning and significance to current design dialogues that the material objects facilitate a forum of discussion.

In fact, this materialist discourse has persistently gained credibility in the last dozen years so that in 2007 MC began

Beatrice Saraga, Wileen Kao, VERTical, installation at the Harvard Graduate School of Design, Cambridge, Massachusetts, USA, 2007, fabrication, detail.

R&Sie, Lost in Paris House, Paris, France, 2008, interior, detail.

its own excellence awards for material innovation in design (e.g. Kennedy & Violich Architecture) and materials (e.g. Concrete Canvas's Concrete Cloth, a cement-impregnated flexible fabric technology). MC then formed a partnership with McDonough Braungart Design Chemistry, LLC (MBDC), and the Environmental Protection Encouragement Agency (EPEA) in 2009 to offer the patented Cradle to Cradle℠ material development services to manufacturers in order to optimize closed-loop industrial cycles. Similar to the professional model, the GSD Materials Collection was conceived as a laboratory, a forum for experimentation and installations, curricular development, publications, exhibitions, independent studies, and thesis preparations. It is seen as an extension of the curricular activities, and as a hybrid structure of "library" and "lab," which is intentionally situated between the library and the wood/CAD-CAM/laser cutting workshops. An investigation of natural and polymeric geotextiles for erosion control, for example, resulted in a prototype of a vertical green wall to test containment systems for soil-less media such as coconut fibers, Hydrogel (super-absorbent) fabric, and expanded shale. Such a speculative platform presents the potential for further affiliations with engineering and material science faculties in order to perform proper testing and patent new products.

Digital

Sanford Kwinter writes in his introduction to Reiser Umamoto's *Atlas of Novel Tectonics*: "When a tree is configured to function as a wood column or beam, it is one set of properties of cellulose that is selected for expression; or more properly, it is the geometry of vascular bundling that selects the properties of cellulose and conveys their felicitous rigidities and flexibilities to the macroscopic scale of the building itself. On the other hand, when a tree is configured into a log for burning, it is the fire itself – that exists already inside of the wood, only dormant or infinitely slowed – that is selected for expression or release. These two forms of expression, chemical and tectonic, are of exactly the same order of physical reality. It is a testimony to the diagram's action that such diverse properties can be called up and released. And it is no small revolution in design to have apprehended this simple but critical fraternity."[20]

Within the database, the decoding of attributes includes lists of terms associated with material composition (e.g. metal, polymer, ceramic, glass); commodity form or structure (e.g. sheet, roll, liquid, textile); process by which the material was fabricated (e.g. extruded, CNC-routed, spun-bonded, thermoformed, woven 3D); and properties, behavioral characteristics and specific attributes (e.g. anti-static, magneto-rheological, nutrient-providing, UV-resistant). This allows for a compound search by any combination of the listed attributes. The selected terms are then hyper-linked to allow cross-navigation.

For example, a search that begins with the term "film" under the category of "form" may result a wide selection of film types, one of which is 3M™ Optical Lighting Film, a transparent polycarbonate prismatic film used to transport and distribute light uniformly in lighting. Its prismatic microstructure is associated with the term "reflective," under the category of "property," then hyper-linked. By clicking on the term "reflective," a new set of materials results, which includes a variety of reflective materials that are not necessarily films, one of which are retro-reflective glass micro-spheres that are used for crosswalk safety markings. While the effect of the white stripes as they retro-reflect upon interaction with car headlights is a commonly known effect, other than road engineers and installers, very few are familiar with the glass beads, or know about their unique process of fabrication.

The clinical (detailed yet detached) dissection of material properties allows for a focus on the specific singularities (properties) and idiosyncratic nature of materials, while at the same time allowing for a "de-specialization"[21] of matter in terms of its prescribed applications; the result of which produces unpredictable solutions. Seen from this perspective, all materials become exceptions to the rule, or in other words, new and innovative. In time, "new" becomes routine, fundamental, or sometimes archaic. In fact, I would argue that the chronological newness of materials is a relatively inconsequential factor of innovation against the process of taxonavigation across the rhizomatic network of data, which provides for infinite pathways of information access and endless sets of interrelation.

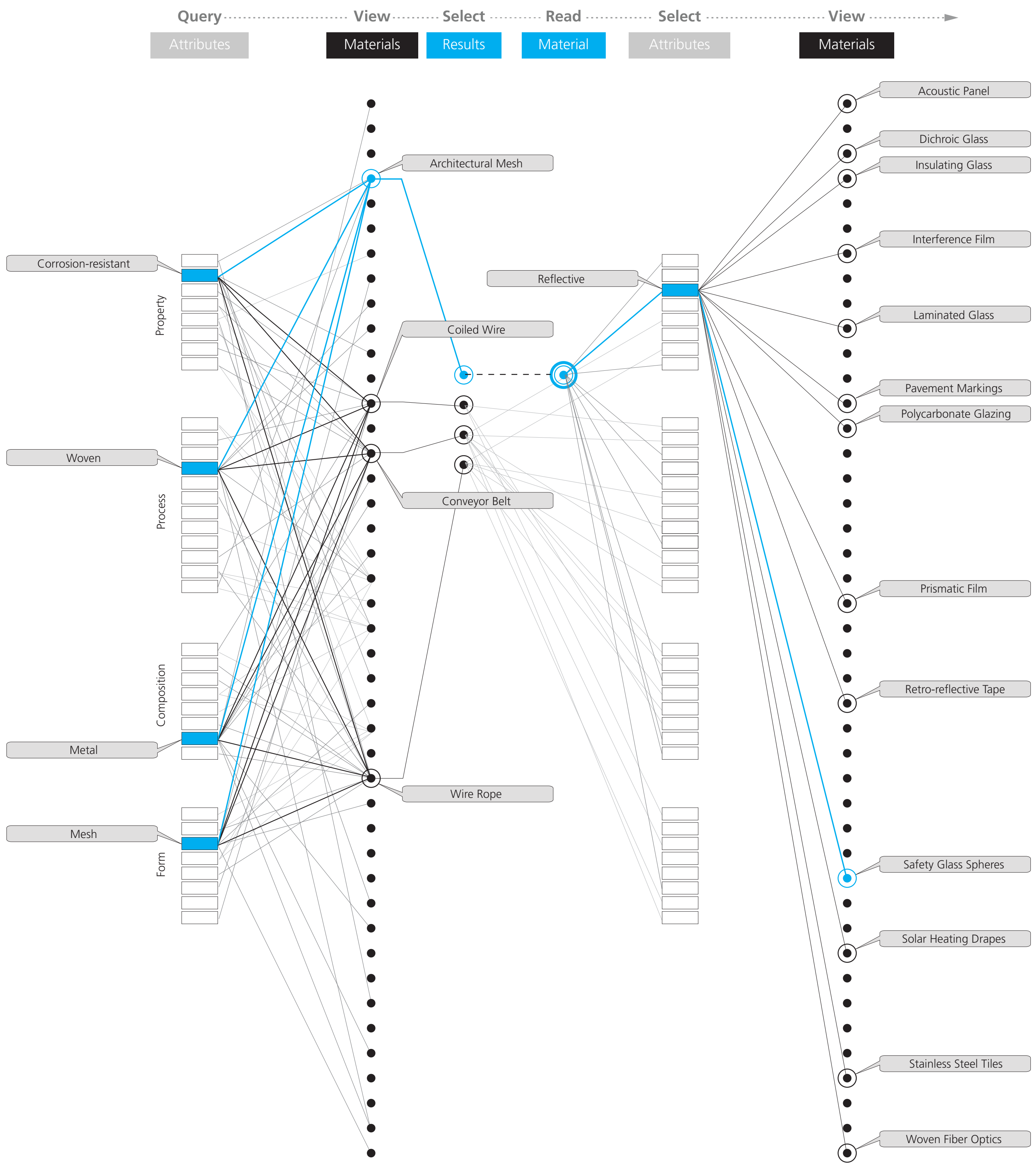
1:1

Alongside data decoding, the photographic display of each material specimen – zooming in to emphasize its grain and microstructure – allows for a scrutinizing of their evidence of formation beyond their totality as a ready-made product for application. In other words, in presenting materials as artifacts with inherent matrices, patterns, and behavioral principles we open up a potential scalar projection of their microstructure to formulate architectural space. The decontextualization of materials from an architectural scale formulates a 1:1 materialist praxis and pedagogy – a scale-lessness that provokes the abstraction of those principles, and likewise, the extrapolation to other scales, other materials, other contexts.

With that in mind, an equally important objective of the accretion of material taxonomy is the appropriation of terminology to generate metaphors for design operations. Publications such as The *Function of Ornament*[22] by Farshid Moussavi and Michael Kubo, and *Tooling*[23] by Aranda/Lasch are two of many examples where operations and structures serve as analytical methods of structural performance and visual effect, or as the articulation of order in computation-driven design. The *Function of Ornament* offers three systems of classification concerning depth, material, and effect. The building's organization is generated by the identified index of operations and fabrication techniques, which then defines the effect and function of facades and thus gives legitimacy to a new kinship of architectural typologies. Neither scientific, nor technologically accurate, the lexicon of material operations in this case is appropriated for a dismantling of the conventional reading of facades, and for the assertion of a functional order of material geometry.

Similarly, the categories of algorithmic techniques outlined within Aranda/Lasch's book *Tooling* – Spiraling, Packing, Weaving, Blending, Cracking, Flocking, and Tiling – address the moments where the formless matter (pre-material) enters the realm of substance and organization (material). The taxonomical indexing, to which they refer as a recipe for programmatic computer code, delineates a procedural thinking for the

Harvard University Graduate School of Design, Materials Collection, online database organization.



properties of their geometries. While the algorithm automates the emergence of shapes, the categorical articulation of the process generates design fodder. "Spiraling produces a shape unlike any other because it is seldom experienced as geometry, but rather as energy." The distinction of the form/shape of a spiral from its emergence – "the evidence of a shape in formation" – allows for yet another definition of materiality, a becoming of form onto itself through processes of fabrication.[24]

Taxonavigation suggests a model whereby the agency of materialism relies upon the premise of speculation rather than specification, in order to transcend the normative perception of material as a mere commodity product. The objective of the contemporary material collections is to give designers both the language and the means to dialogue with scientists and manufacturers and actively influence technological trajectories. Equally paramount is the ambition to generate distinct and prolific scholarship concerning materialism, such that it can interchange between its technical and theoretical constructs and consequently provoke invention. It is therefore essential to frame materialism as inherent to the design process, and as such employ open-ended tools that can elaborate upon this particular relationship and likewise, elicit latent ones.

Notes

1. Kula, Daniel, and Élodie Ternaux (matériO). "Reflections on Hyperchoice" and "De natura materiae" in *Materiology: The Creative's Guide to Materials and Technologies*. Amsterdam: Frame Publishers/Birkhäuser: Basel, Boston, Berlin, 2009. p. 313.
2. Daston, Lorraine. "Speechless" in *Things That Talk: Objects Lessons from Art and Science*. New York: Zone Books, 2008. p. 23.
3. Gausa, Manuel *et al*. *The Metapolis Dictionary of Advanced Architecture: City, Technology and Society in the Information Age*. Barcelona: Actar, 2003. p. 15.
4. *Ibid*. p. 14.
5. *Ibid*.
6. Kula, Daniel, and Élodie Ternaux (matériO). "Reflections …" p. 326.
7. *Ibid*. p. 313.
8. Daston, Lorraine. "Speechless" … p. 17.
9. Addington, Michelle, and Daniel Schodek. *Smart Materials and New Technologies for the Architecture and Design Professions*. Oxford: Architectural Press, 2005. pp. 25-26.
10. *Ibid*. p. 26.
11. *Ibid*. p. 25.
12. "Mondo Materialis" was subsequently featured in various venues including the Cooper-Hewitt National Design Museum.
13. "Mutant Materials": http://www. mutantmaterials. com/
14. Kennedy, Sheila, and Christoph Grunenberg (KVA). *Material Misuse*. London: Architectural Association, 2001.
15. The 17th-century Wunderkammer is described as a collection of wonders, of the new, rare, and unusual – an encyclopedic collection of all kinds of objects and materials of dissimilar and diverse origin. Such collections were the expression of the discovery of the New World, an Age of Exploration, "a period of rapidly expanding horizons of knowledge and the constant attempt to achieve the seemingly unachievable." These compilations were intended as "a microcosm of the Universe – a macrocosm;" a mirror of contemporary knowledge, "regardless of whether those objects were created by the genius of man or the caprice of nature. The rarer an item, the more attractive it appeared, be it a colossal 'giant's' bone or a precious find from a mineral vein turned into a sparkling jewel by a famous goldsmith." See Wolfram Koeppe, "Collecting for the Kunstkammer" in *Heilbrunn Timeline of Art History*, New York: The Metropolitan Museum of Art, 2000. – http:// www. metmuseum. org/toah/hd/kuns/hd_kuns. htm
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