Introduction

Toward a New Culture of the Material

Materials found on Earth occasionally have a history that predates our planet's existence. From this perspective, human material culture spans a relatively brief duration of 2.6 million years. In the early nineteenth century, Danish antiquarian Christian Jürgensen Thomsen classified the human being's own history and prehistory based on the use of materials, thus inventing the notion of Stone, Bronze, and Iron Ages. At that time, and in contrast to these distant times, the dawn of industrialization initiated a period of excessive extraction of materials, notably coal and iron, that shaped the latest material age in just 200 years: Modern technology, as a strategy for dominating nature, is based on controllable substances—particularly iron, steel, concrete, glass, and plastic—which all rely on materials to fuel the processing heat required to melt, move, and burn them. Only recently has it become evident that this ongoing age of destructive technological production is aggravated by the even more destructive impact of using its artifacts.

The actual ecological crisis is largely caused by the domination of nature combined with a disregard for the materials' own activity. As awareness of this situation grew, however, the analysis of the materials' usage in the biological realm showed a different picture: Long before human beings came into existence, bacteria, fungi, and plants developed practices that correspond to the materials' intrinsic activity rather than try to passivate it. Carbon, hydrocarbons, cellulose, and water are the highly active building materials of life and, as such, exhibit a sophisticated entanglement of matter, activity, and energy that may serve as a basis for the research and design of bio-inspired materials. Moreover, numerous non-industrial practices like fermenting, woodworking, weaving, and medicine, along with artistic endeavors, vividly illustrate an engagement with material activity. Although these practices have often faced challenges due to colonialism and extractivism, some of them have continued to this day, sometimes in new forms.

Our focus on active matter reverses the modern notion that raw materials (*Rohstoffe*) have to be made into suitable and obedient tools and means (*Werkstoffe*) that humans use. Taking the intrinsic activity of materials not as a failure or malfunction but as a dynamic sensorimotor structure offers a completely different starting point for designing artifacts.

It is the main objective of the Cluster of Excellence "Matters of Activity" to raise awareness of this fundamental change by combining the perspective of the humanities and their critical historical and theoretical approach with the perspective of the natural sciences and their new avenues of experimentation with the bio-technical principle of materials' activity, and above all with the transformative procedures of design. To achieve this, the Cluster has established dense interdisciplinary collaboration between more than forty disciplines, creating an integrative process for analyzing and designing with active materials.

 https://doi.org/10.1515/9783110714883-001

Boundary Objects

Our research pursues two main goals: to pave the way for a new culture of the material in the digital age and to create a collaborative academic structure for interdisciplinary knowledge production that aims at its own "materialization" through the incorporation of architecture and design and the exchange with societal practices.

This interdisciplinary collaboration does not start out from a common language—still to be achieved—but from materials that constitute different but equally challenging features for all participating researchers. Active materials—such as cellulose and water—take the role of boundary objects in at least two fundamental respects: they serve as interfaces between and translate across diverse methodological approaches; and since they belong to multiple worlds simultaneously, their analysis integrates very different approaches, both natural and cultural. In the Cluster, material activity is analyzed by focusing on weaving, filtering, and cutting as elementary boundary practices. As procedures which are not simply applied to materials, they have to be considered as triggered by the materials themselves. The vascular structure of human organs, the cellulosic extracellular matrix of biofilms, the fibers of plant or fungi tissues, and the tessellated and elastic surfaces in plants and animals all raise questions of how artifacts fundamentally change when they are designed according to the principle of intrinsic agency. With these elements, we build up a material repository of high heterogeneity, a kind of *matériauthèque* with samples such as seed capsules, rubber, or wood, which represents a new world of soft mechanics, sensing tools, or self-acting structures.

Shaping

From the perspective of an interactive relationship between materials and their designers, users, or perceivers, form processes and object constitutions cannot be regarded as merely human-caused. Rather, we are dealing with a kind of multilayered mutual articulation in which materials, objects, and environmental properties are participants that are just as active as ourselves, animals, or plants. Shaping and being shaped by active matter leaves neither side unchanged. As a result, clear cut distinctions between action and perception, or doing and undergoing, become porous.

When studying atmospheric phenomena such as clouds or aerosols, engaging with the quasi-liveliness of our surroundings leads us to refine our practical and theoretical sensorium, and to design *with* active material rather than silence it. In the realm of neurosurgery, investigating the intricate dynamics between human and nonhuman agents within the surgical setting can enhance our comprehension of how the material world both forms and is formed by human activities. The surgical knife becomes an extension of both the surgeon's body and the patient's body. The act of performing and undergoing a cutting line converges within the instrument itself: shaping and sensing are two sides of one and the same process. Apparently, human senses

have developed along with the tangible and comprehensible world. In order not to lose the feel for exploratory probing, one must remain open to invigorating contingencies and blurred boundaries of all kinds. The same applies, eventually, to processes of conceptualization in science. Scientific subject matters tend to be no less active than palpable ones—all the more so when they are tackled within an interdisciplinary framework. To acknowledge the tentative, vague, and not-yet-understood, or even to deliberately head towards it, means keeping concepts and terminologies in vibrant plasticity.

Collaborative Practices

As we withstand giving definite answers rooted in individual disciplines and dare to open a conversation on manifold collective questions, a new form of complexity arises. But what is instigated when we begin doing research in and for a messy world? Complex realities, as they occur in boundary objects, require correspondingly complex ways of dealing with them. This could mean entering into a "dance of agencies" which readily invokes how these practices are entangled between material, immaterial, and more-than-human actors. As a result, our path "toward a new culture of the material" may be found somewhere amongst more nonlinear or volatile approaches, and multiple modes of collaboration. They lead us to investigate the plasticity of hygromorphic willow as a responsive filament, conduct trials on programming auxetic surfaces with and from paper, and reveal catalyst values of filtering in cross-disciplinary environments. Such an endeavor is necessarily a collective one, growing as an organism of many parts between the humanities, sciences, and design toward more open futures.

Growth

But what happens when we move beyond predominant paradigms of control, exploitation, and domination? Maybe new common ground is constituted by shifting from the logics of efficiency and optimization towards more open-ended understandings of creation as growth, by embracing material indeterminacy, microbial activity, and behavior over time. The resulting models of how forms grow could mediate between bio-inspired takes on the whys and hows of "making," ranging from bacteria as collaborative environments of active structures to biofilms as agents that fold, buckle, and wrinkle into as-yet-unknown patterns and morphologies.

Such relations of matter and form are dynamic by nature, translated within processes of emergence, growth, and adaptation, resonating equivalently in realms of the nonliving, the living, and the conceptual. Inspired by morphological practices of nurturing, cultivation, and growth that are ubiquitous in nature, understandings of authorship entrenched in the world of standardized materiality and industrial production are

abandoned in favor of more mutual and co-designed processes. In turn, and probably counterintuitively to some, growth can refer to both gaining and losing form, thus affording a perspective on the relation between structure and material that teaches us to conceive of moments of disturbance and crisis also in terms of their potential.

Indeterminacy

In view of various environmental and perceptional tipping points, our prevailing concern—and, in the case of aesthetic experience, also our playful tension—arises from the ambiguity and unpredictability of material-based form processes. In efforts to stabilize them, it becomes apparent that certain aspects persistently evade control. This phenomenon manifests itself in various ways: sea gates struggling against high tides, captions on photographs that fail to fully encapsulate the ambiguity of an image, or the human tendency to seek patterns in the fluidity of active materials. Within the anthropocentric paradigm, controllers and masters have benefited from extracting and stabilizing matter. Active materials, however, invite many more transformative interactions.

Humankind is embedded in larger open systems. Rather than seek control, we must learn to face uncertainty and partake in the continuous process of *poiesis*, which is particularly evident in transitional spaces. In these in-between realms where moments of equilibrium and stability are an anomaly, entities like the so-called duckrabbit encounter a landscape that is both terrestrial and aquatic. The potential of ambiguous imagery unfolds through relationships that entail mutual transformation. By paying critical and caring attention to such phenomena, one can merge and flow with transformative materials while imprinting their fluctuations as enduring memories.

Memory

The notion of memory as a space of storage and retrieval poses the problem of how a static reservoir can be suitable for recognizing something in a world of constant flux. In programming, memory is seen as an adaptive constructive dynamic that regulates its conduct on the basis of continuous recategorization and can only be detected while it is operating. In memory research, the difference between storage and operation has an equivalent in the distinction between explicit and implicit or declarative and procedural memory. Procedural memory is not located in a specific spot but *takes place*, be it in automated actions, sensorimotor recurrences, or in the so-called shape memory of materials. Material activity is rooted in both its memory and its potentiality, which are present as past and possible future states and processes. Here, potentiality can be understood as a possibility of becoming, a disposition to change with both an active and a passive side. While the active side is the ability to change something (or to change oneself), the passive one lies in the capacity to be changed and take on a different form. In preservation practices, the notion of material activity as a po-

tential that can be heightened or halted takes on a further dimension. Wax, for example, due to its extreme malleability, stores the history of its processing down to the most unintentional traces. Inadvertent movements of the shaping hand and fingerprints are recorded as well as what can be regarded as planned processing. What if our focus on conservational efforts would shift from the fixation of states and results to this oscillation between activity and passivity, and to the transience and even decay of objects? In an Anthropocene dystopia in which the destruction of our habitat is imminent, this issue could be accentuated in yet another way: What should endure and be preserved in an imaginary museum when nothing remains of the world as we know it, including ourselves? Arguing with speculative archaeology, the "fossilization" of the greatest possible diversity, of delicate materials and fragile forms, could create a memory of precious and promising dynamics—a refuge in which memory and potentiality coincide.

Energies

Cultivating an attunement to the potentialities of a material-based and process-oriented memory necessitates developing a specific sensitivity—an ability to detect the latent energies in both the material and the symbolic realms. It calls for an acknowledgement of material activity as a new mode of symbolic material operation.

Felt, a fabric composed of densely interlocked animal hairs, functions as an effective insulator thanks to its physical properties. Furthermore, when worn, the vitality of the animal is transferred to the wearer. In this case, the symbol embodied by felt is not merely abstract but tangible and operational, influencing its interaction with its surroundings—its intertwining structure has enabled felt to even become a political symbol of democracy.

The structure of a material acts as an adaptive framework, allowing it to respond to environmental stimuli. This becomes particularly evident in biomaterials, where the interplay of internal interfaces and changes in free energy—influenced by humidity, entropy, and the shifting temperature patterns entailed by global industrialization—orchestrates their behavior. For instance, a seemingly inert sheet of paper undergoes immediate transformation upon contact with water, the latter acting as a catalyst, forging interactions at the molecular juncture that it forms with the cellulose fibers of the paper. Such phenomena emphasize the role that materials play as open adaptive systems. Intrinsic structures of active materials can be regarded as analog codes that not only symbolically represent but also physically execute their information at the same time. In recognizing this symbolic dimension of matter, the triadic relationship between material, energy, and information is redefined, heralding a paradigm shift in our engagement with material. The principle of active matter is a game changer—with the potential to cope with the challenges of the modern world and to conceptually and practically transform it from within.