Homeostatic Designs: How the Theories of Antonio Damasio Can Inform Design Thinking

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Abstract
This paper discusses the role of homeostasis through the lens of the neuroscientist Antonio Damasio and its potential relation to design. The understanding of physiological regulation has evolved from the Greek idea of body humors, through Claude Bernard's "milieu intérieur", to Walter Cannon's formulation of the concept of "homeostasis. This evolution was important to the homeostasis concept. However, these views of homeostasis do not usually conjure up the fact that there are two kinds of control of internal milieu parameters. The first one is the traditional one: a non-conscious form of physiological control which operates automatically without awareness or deliberation on the part of the organism. There is a second, additional regulatory system in humans and most animals that can be conscious and involves feelings of the simplest variety, also known as homeostatic feelings. Feelings are the main contribution of Damasio to homeostasis theories. It is important to understand what homeostatic sensations are and how they function because how we feel can start to serve as homeostatic guides. The relevance of the body's homeostasis and emotional reactivity in our brain is becoming increasingly evident in neuroscience yet difficult to incorporate into the design fields; therefore, this paper offers an opportunity as a line of research inquiry. Discussing homeostasis theory in design offers insight into how this can contribute to the built environment, privileging design and outcome.

Keywords: Antonio Damasio, Neuroscience, Design, Homeostasis, Well-Being

Introduction

The scientific validity of the hypotheses related to psychology, psychoanalysis, and phenomenology addressed in design has been supported by contemporary neuroscience research and rigorous methodologies. This paper debates the role of homeostasis through the lens of the neuroscientist Antonio Damasio and its possible connections to design. Damasio's research has contributed to understanding the neurological foundation for feelings and emotions, as well as demonstrating the importance of affect in social cognition and decision-making. His work has significantly impacted our present knowledge of the brain mechanisms that underpin memory, language, and consciousness (Faculty Profile, n.d.). Besides all the research he has been developing, perhaps Damasio's Homeostasis Theory might be the most useful for design discourse. For him, homeostasis is a state in which human physiology is maintained within a range that allows survival and flourishing: a balance of energy with a surplus capable of ensuring a future (Man and Damasio, 2019). It is mainly defined as a self-regulating process by which an organism can maintain internal stability while adjusting to changing internal and external conditions, resulting in well-being (Damasio, 2018).

The understanding of physiological regulation has evolved from the Greek idea of body humors, through Claude Bernard's "milieu intérieur" (Bernard, 2013), to Walter Cannon's formulation of the concept of "homeostasis" (Cannon, 1929). The theory of the four humors (blood, phlegm, yellow bile, and black bile) first appeared with the Hippocratic treatise called The Nature of Man, in which good health is defined as the balance and mixture of the humors, and their imbalance and separation are causes of disease (Hippocrates et al., 1931). Claude Bernard was a French physiologist who first described the idea of homeostasis, analysing that plants were capable of plenty of nonobvious, stealth movement (Damasio, 2021). Their network of underground roots grew toward the region with most water and nutrients. Walter Cannon, an American physiologist, coined the word "homeostasis" and the application of control theory (feedback and feed-forward regulation) to explain how a constant internal environment is achieved (Cannon, 1929). This evolution was important to the homeostasis concept.

However, these views of homeostasis do not usually conjure up the fact that there are two distinct kinds of control of internal milieu parameters. The first one is a non-conscious form of physiological control which operates automatically without awareness or deliberation on the part of the organism (traditional concept of homeostasis). For example: when water balance is low, the kidneys automatically slow down their operation to reduce diuresis and restore hydration (Kotas and Medzhitov, 2015). The conventional concept of homeostasis draws attention to this non-conscious physiological control without the organism's awareness or consent. Still, there is a second regulatory system in humans and most animals, besides automatic control, that involves feelings (Damasio and Damasio, 2016; Damasio and Carvalho, 2013); the main contribution of Damasio to homeostasis theories (Damasio, 2021). This second regulatory system involves simple feelings, also known as homeostatic feelings, that resolve critical life-control issues. Examples include thirst, hunger, desire, pleasure, well-being, malaise, and certain kinds of pain.

Therefore, feelings are regulatory interfaces with a double side. The first is that feelings are regulatory interfaces partly related to standard physiological operations. These include the chemical and cellular mechanisms that typically allow for the automatic regulation of internal body variables. However, the other side of feelings is mental, providing organisms with something evolutionarily new: a direct and explicit experience. It enables the person with

such experience to perceive the state of their organism. For example, airway entering the lungs limitation when someone is submerged. Our organism has a quick and automatic motor response to acquire access to air. The fact that this reaction is also perceived as air hunger and panic is a plus that ensures our attention to the organism's danger. So, the feeling experience has a content that refers to what the feeling describes, for example, difficulty breathing. Also, it has an intensity (weak or strong) and valence (positive or negative) that gives a pleasant aspect (joyful, energetic, relaxed) or unpleasant aspect (disagreeable, painful, sick). The sum of these emotional dimensions is informative as it tells the individual whether the current state of the organism is usually conducive to sustained health or flourishing, for example, well-being, or whether it needs to be corrected, in a quick, summary style (hunger, malaise). Feelings, in other words, are regulatory interfaces that provide information and transform the individual into a potential regulator. The fact that feelings are felt in the mind motivates the organism's owner to behave and encourages learning. Memory efficiency increases when a situation is present via mental states imbued with positive or negative valences, incentives or disincentives, and attractive or aversive conditions (Damasio and Damasio, 2016).

In addition, feelings may strongly impact reason. The brain systems needed for both are intertwined together with the systems that control the body. It appears that a drive that begins in the brain's core and spreads to other levels of the nervous system and manifests as either feelings or unconscious biases to guide decision-making (Damasio, 2005). The conscious feeling of homeostatic regulation engages with complex affects, drives, motivations, and emotions shaped through evolution and individual sociocultural experiences. The responses to homeostatic feeling states are influenced by the basic homeostatic variable and many of the phenomena associated with affect processes and cultural group tuning (Damasio et al., 2000). Frequent engagement of such responses through time adds to building human preferences and, ultimately, what is known as rationality in individuals and cultural communities (Damasio and Damasio, 2016; Damasio, 2000). It is important to understand what homeostatic sensations are and how they function because they could guide the design process. How we feel then starts to serve as a homeostatic guide and helps us to achieve well-being.

The traditional concept of homeostasis doesn't capture the depth of the notion and the range of situations in which it can be applied to biological systems. The purpose of this paper is to take a broader look at homeostasis, according to Damasio's theory. It comprises systems in which the presence of conscious and deliberative minds, both individually and in social groupings, allows for the establishment of additional regulatory mechanisms aimed at creating balanced and thus survivable living states (Damasio and Damasio, 2016). This essay proposes that design can be an example of such a regulating mechanism and that information about human homeostasis could be useful in studying this field. It raises some questions such as: how might the Theory of Homeostasis contribute to understanding perception in design? Could design be seen as an extension of ourselves, acting as psychic stabilizers or destabilizers? How might design play a role in the concept of homeostasis or allostasis? It discusses how the reality of human homeostasis expands the views on preferences and rational choice and how designers could use feedback to create projects with greater intelligence and performance. It pins emotions and feelings as basic forms of cognition. Also, it affirms their importance in well-being, especially because emotions and feelings have been undermined in neuroscience and design discourse for a long time.

Since the relevance of the body's homeostasis and well-being (Damasio et al., 2000) is becoming more and more obvious in neuroscience but difficult to include in the design fields, this work provides a distinct prospect as a line of scientific investigation. Discussing the Homeostasis Theory provides insight into how this may enhance the built environment in a way that prioritizes design and outcome. It places this work within a larger field of design theory aligned with neuroscientist Antonio Damasio's survival concept, which relies on the homeostatic range for optimized life regulation.

Finally, for this paper's purpose, the word "design" will embrace the fields of design and architecture because these blurred identities help us focus on the process and relationship between person, outcome, and environment rather than the result itself. It also stimulates new intersections between those disciplines and dissolves pre-established functions and characteristics.

How the Theory of Homeostasis might contribute to understanding perception in design

According to Damasio, the Central Nervous System (CNS) continually monitors our interior and exterior environments. Changes in the external environment are perceived via the exteroceptive senses (smell, taste, touch, hearing, and sight) and changes in the internal environment (the degree of contraction of visceral muscles, heart rate, levels of metabolites in the internal milieu, among others) are sensed by the interoceptive system (Craig, 2003). The main contributors to interoception are chemosensation, thermo-algic sensation (temperature and pain perception) and visceral sensation (Craig, 2003; Parvizi and Damasio, 2001). Also, proprioception, the vestibular sense and light and non-discriminative (‘limbic’) touch may constitute additional interoceptive modalities (Parvizi and Damasio, 2001; Olausson et al., 2002; Damasio and Carvalho, 2013). The interoceptive process begins with peripheral sensing of homeostatic changes, whether visceral or humoral. It plays an essential role in producing feelings and, specifically, accounts for their subjectivity: the fact that they are spontaneously conscious (Carvalho and Damasio, 2021).

The neuroscientist Anil Seth complements that by stating: "Perception doesn't depend largely on the signals coming into the brain from the outside world (exteroception), it depends as much or if not more, on predictions flowing in the opposite direction…Our experiences of being an embodied self are more about controlling regulations than figuring out what is there" (Seth, 2014; Seth, 2017).

If design focuses on creating perceived value for the user through the physical and psychological bonds, they develop with the outside world, using sensory experiences to evoke positive feelings can increase design value (Becerra, 2016). The tricky part is that positive feelings can be elicited even with a stimulus not perceived as happy. As stated by Damasio, for instance, music perceived as sad can lead to mixed" emotions, in which positive and negative affects are experienced simultaneously, or even to a positive affective state. This situation happens when the music is aesthetically pleasing, promotes psychological and emotional rewards such as understanding feelings and emotional assurance, triggers specific memories and distracts from current problems, and engages imaginative processes and intense emotions without real-life implications. There is an interaction between personality, social context, learned associations, and mood in pleasurable responses to sad music. How these factors interact can be understood from the perspective of homeostasis regulation (Fig.1). When and how music elicits a pleasurable response may depend on whether or not there is an initial homeostatic imbalance and whether or not music can successfully rectify it.

If there isn't a pleasant response to sad music, there may not have been a homeostatic imbalance, or the musical stimulus did not correct the imbalance (Sachs et al., 2015).

This paper proposes that design, such as art, allows for various emotions to be experienced and expressed indirectly and without the need for language and might have the capacity to communicate, regulate, and enhance emotions. So, it could help an organism or a group to a state of homeostatic equilibrium. For instance, if there is a distressing situation, generating a negative mood and an absorptive kind of personality, seeing something sad but aesthetically pleasing could make the person focus on the beauty of the design, repairing their negative mood and correcting the previous homeostatic imbalance. In the same way, if a person is in a neutral mood but has a personality that is open to experience, seeing something sad could induce a variety of emotions, causing pleasure and experiencing an optimal state of well-being. So even a culturally considered "sad color" on a space or a "sad photography" can lead to a positive affective state if a homeostatic imbalance existed previously and was corrected. This point is interesting because a design's affective state might depend on an ongoing homeostatic control: the relationship between the user's personality, background, context, and mood might be more important than the individual and situational factors associated with enjoying a design.

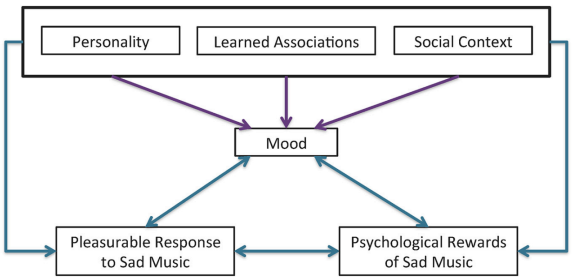

Figure 1: Influence of a person's mood
Retrieved from: Sachs et al., 2015

Figure 1 shows that personality, learned associations, and the social context can influence a person's current mood, and the interaction of one's mood with certain combinations of these three factors form the psychological rewards associated with sad music and, ultimately, the pleasurable response. The resulting pleasurable response can, in turn, influence the current mood, and there is a reciprocal nature between psychological rewards and pleasurable responses.

The neuroscientist Chatterjee extends that thought by saying that the environmental signals that give rise to aesthetic judgments might be born from those that regulate biologically more fundamental behaviors. We could manipulate design parameters to heighten these adaptive evolutionary responses for aesthetic sensation and emotion. For him, the aesthetic experience relates to a triad of knowledge and meaning, sensory-motor, and emotion-valuation (Coburn and Chatterjee, 2017). Herry Malgrave complements that "Emotion becomes an aesthetic value that shapes who we are and what we perceive" (Mallgrave, 2013), and Neil Leach points toward the important social role of the aesthetic domain as a means of reinserting the individual within society (Leach, 2006).

Therefore, this paper suggests that designers could pay attention to external stimuli and how they affect what we perceive, but also to homeostasis and how it affects what we perceive. It

could be interesting to emphasize a homeostasis-based, inward-directed perception. Could designs address ongoing homeostatic imbalances, physical and psychological? Especially nowadays, with biodata measures, wearable technologies, and Quantified Self practices? (Macruz et al., 2022)

Could be seen as an extension of ourselves, acting as psychic stabilizers or destabilizers

In Damasio's Theory of Consciousness, every person has more than one state of consciousness. The conscious mind is formed by the mind that receives a flow of sensory information from our senses and the self, which introduces a subjective perspective. The self is always felt: you can see something and "feel that you see". Damasio traced a gradual progression of self-processes; according to him, three levels of self can inhabit the mind: The "Protoself," which is the feeling of knowing that my body exists, and the "Core Self", that is the feeling of knowing that my organism has relationships with objects and events and I can act upon them, and the "Autobiographical Self " that is the feeling of knowing that I am me and I have a memory: I know that I have a past and a future and social and cultural relations. Going through the progression of self-processes is the theme for homeostatic regulation because the self is a repeatedly reconstructed biological state. (Damasio, 2005).

The neural substrate for the self inhabits with the continuous reactivation of at least two sets of representations. One set relates to significant events in a person's autobiography, which can be used to reconstitute a notion of identity repeatedly. In essence, a significant portion of the state of self is comprised of the continual reactivation of new representations of our identities (a combination of memories of the past and the anticipated future). By the time we take an assessment of the present, it has already become the past. We are preoccupied with making plans for the future, which we accomplish by building on the foundation of the past. There is never a present. The second set underlying the neural self consists of the primordial representations of a person's body: not only what the body has been like generally, but also what the body has been like recently, just before the processes leading to the perception of an object. Subjectivity may depend greatly on the changes in the body state during and just before the processes leading to object perception. So, a representational object, a responding organism, and a state of self-evolving due to the organism's response to the object are held simultaneously in working memory and attended, side by side or in rapid interpolation. (Damasio, 2005).

Understanding the three levels of the self and the importance of subjectivity, could we design for different states of consciousness? For instance, patients with Alzheimer's tend to remember the things that are emotionally charged, such as their first house and native language. Could we use affective memories as emotional strategies to ground them and empower them, helping them to use an object or navigate a space? Could we focus on the identity of the users, individual histories, familiarity, and empowering them? This paper suggests the term affective functionality because this could be seen as an optimization related to physio psychological data.

Therefore, Damasio’s theory shows that the environment is never static. It is constantly updating itself, it is different for every person, depending on the self, and it is different for the same person because of the updated mental construction and varying consciousness with circumstances. As a prerequisite for existence, one must constantly uphold and maintain the boundary between oneself and their surroundings. This concept is closely related to Autopoiesis’ created by the neuroscientists Francisco Varela and Humberto Maturana, in

which systems continuously construct themselves and define their own relations to the environment (Maturana and Valera, 1980).

Damasio hypothesizes that primordial images of the body in action might have influenced consciousness. The brain would represent what we currently consider a three-dimensional space based on the body's anatomy and movement patterns in the environment. They would serve as a core for the neural representation of self, providing a natural benchmark for what occurs to the organism inside or outside of its boundary (Damasio, 2005).

This view is similar to the psychologist James Gibson. He says that the words animal and environment are linked; the meaning of each term is implied by the other. Without its surroundings, no animal could survive. He redefined visual perception as the involvement of the entire organism as it moves through the surroundings. So, perception is the process of actively obtaining invariants or patterns from the environment and animal behavior is controlled by what he calls "affordances", how animals perceive possibilities in the environment (Gibson, 2014).

However, according to Damasio, our body as a whole and our brain take part in the interaction with the environment. "Think of viewing a favorite landscape. The iris not only lets light through but also adjusts its size and shape in response to the scene before them. The eyeball is positioned by several muscles to track objects effectively, and the head and neck move into optimal positions. These adjustments depend on signals from the brain to the body and related signals in vice-versa direction. Subsequently, signals about the landscape are processed inside the brain…As knowledge pertinent to the landscape is activated internally from dispositional representations in those various brain areas, the rest of the body participates in the process. Sooner or later, the viscera are made to react to the images you are seeing, and to the images, your memory is generating internally, relative to what you see. Eventually, when a memory of the seen landscape is formed, that memory will be a neural record of many of the organismic changes just described, some of which happen in the brain itself (the image constructed for the outside world, together with the images constituted from memory) and some of which happen in the body proper" (Damasio, 2005).

Therefore, to comprehend the environment, more than merely direct brain impulses from given stimuli are required, let alone seeing visual images. The body actively adapts itself to facilitate the best interaction possible. The fact that the organism needs environmental interactions to sustain homeostasis is maybe no less significant as to why most environmental interactions occur. The organism constantly interacts with its surroundings (actions and exploration came first), allowing it to facilitate the interactions required for survival. But to successfully escape danger and be effective at finding food, sex, and shelter, it must be able to detect its surroundings (via smell, taste, touch, hearing, and sight), allowing it to respond appropriately to what is sensed. As much as it involves receiving messages from the environment, perception also consists in acting on it. In essence, brain circuits continuously represent the organism as it responds to and is influenced by stimuli from its physical and sociocultural environments. (Damasio, 2005).

Andy Clark contributes to that view, pointing towards the concept of "extended mind". As stated by him "with the advent of texts, PCs, coevolving software agents, and user adaptive home and office devices, our mind is just less and less in the head. In other words, the separation between the mind, the body, and the environment are seen as an unprincipled distinction." (Clark, 2004).

So, if the environment is never static, neither might be design. This paper proposes that design is constantly updated with the construction of the conscious mind, which in turn affects the design, affecting the conscious mind in a feedback loop. Following this line of thought, design would be an extension of ourselves, an "extended mind", constantly re-defining us and sustaining our homeostasis.

How design might play a role in the concept of homeostasis or allostasis

According to Damasio, first, only a portion of the brain's circuitry is determined by genes. The human genome specifies the overall design of the brain and our bodies in detail. However, not every circuit actively develops and functions as determined by genes. At any given time in adulthood, a large portion of each brain's circuitry is unique and individual, reflecting that specific organism's history and environment. Second, each human organism functions within clusters of like beings. The mind and behavior of people who are a part of these collectives and who live in particular cultural and physical settings are not solely shaped by the activity-driven circuitries. They are even less shaped by genes alone. It is important to consider human behavior's social and cultural background to comprehend how the brain creates the human mind (Damasio, 2005).

We were born with a built-in system that would allow us to experience both pain and pleasure. The threshold at which it starts to be triggered, its intensity, or our ability to reduce it can all be affected by culture and personal history. But the necessary tool is a given. Suffering alerts us to something. The likelihood that people will pay attention to pain signals and take action to stop their source or reverse their effects is increased by suffering, making it the best form of protection for survival. It follows that behavioral impairments should accompany changes in pain perception since pain is a lever for effectively deploying drives and instincts and developing related decision-making strategies (Damasio, 2005).

Civilizations are transferred throughout people and generations through language, the items, and rituals that the cultures developed in the first place. The process of creativity and cultural innovation might have been continued and monitored by cognitive means and the actual felt value of life outcomes. In his theory, connecting cultures to feelings and homeostasis deepens the cultural process's humanization and increase their ties to nature. Feelings and creative cultural brains were created throughout a long process in which homeostasis-guided genetic selection played a key part (Damasio, 2018). In line with this thought, design could play an important role in building culture.

The neuroscientist Lisa Barrett complements this view, by describing how culture is important to regulate our nervous systems (Barrett, 2017; Barrett, n.d.). She states that we collectively impose meaning to certain signals that they do not have on their own, and our ability to agree on what something means is essential to regulate our nervous systems. So, the brain imposes meaning on the signal itself, and that is how we create and nurture our social realities. "If you grow up in a culture that does not have the concept for sadness, you don't experience sadness, and you don't perceive sadness because your brain becomes wired to make metal events that are existing in your particular culture." (Barrett, n.d.).

She expands that thought by saying that we also regulate our nervous systems and other people's because the metabolic cost of the brain is expensive, and evolution couldn't make our brains any bigger. Hence, it trained other brains to regulate ours as well. "You can affect the nervous system of someone by just speaking on the telephone because they feel affected

or connected only by your voice because we are social animals…When you are feeling horrible, and someone gives you support, says kind words, or hugs you, they are physically interfering with your body. The other person is helping your body maintain allostasis when it probably can't do it by itself." (Barrett, n.d.). Allostasis is the active process of maintaining or regaining equilibrium. (McEwen and Wingfield, 2010). The basis of love or affection is the ability to affect someone's allostasis." (Barrett, n.d.).

Neil Leach extends that by saying that cities and towns themselves must be understood as amalgams of 'processes', as spaces of vectorial flows that 'adjust' to differing inputs and impulses, like some self-regulating system (Leach, 2022). Lovelock also expands this concept by posing the earth as a self-regulating entity (Lovelock, 2016).

In Damasio's Somatic Maker Hypothesis, homeostasis is the basis of emotions and behaviors, experienced as punishment or reward, pain or pleasure, affecting decision making, learning, attention, memory, reasoning, creativity, social functioning, morality, and human ethics. If humans are fundamentally emotional and social creatures, these processes mentioned previously are emotional, embodied, and social (Damasio, 2005). This understanding expands our views on preferences and rational choices. It raises the question of how designers could use feedback to create projects with greater intelligence and performance, emphasizing embodiment, emotion, and social processes.

Two scientific experiments are interesting for the understanding of embodiment. The first one is called the Rubber Hand Illusion, in which the person's real hand is hidden from view, and the person stares at a fake rubber hand. Both hands are simultaneously stroked with a paintbrush while the person looks at the fake one. After a while, this leads to the sensation that the fake hand is part of the body. The congruence between seeing touch, and feeling touch on an object that looks like a hand and stands where a hand should be is enough for the brain to make the best guest that the fake hand is part of the body (Seth, 2017). The second one is called rubber hand illusion in virtual reality. It is a virtual hand that flashes red and back-in-time and out-time with people's heartbeats. When the heartbeat is in time, people have a stronger sense that it is part of their body. So, the experiences of having a body are deeply grounded in perceiving our body from within (Keisuke et al., 2013). These experiments might suggest that a physical or digital design aligned with the body could be a more effective feedback strategy to modify our affective state.

Therefore, would it be possible to enhance this interrelationship between environment, design, and people? Could new technologies help extend our perception and transform us, improving this triad? Could design be more interactive, making people more aware of its effect, affecting people's behavior that affects back design? As Damasio points out, the use of soft robotics, cross-modal information processing, and multisensory integration could help us to embrace ambiguity, redundancy, feedback, and abstraction (Man and Damasio, 2019; Man et al., 2013). An open-ended design structure like this might be helpful to gain more interactivity between the environment, design, and people. Lastly, how might design play a role in the concept of homeostasis, allostasis and well-being?

Conclusions

Contemporary neuroscience and rigorous methods are used to support theories that relate to architecture and design. This paper explores the function of homeostasis and its potential connection to design through the eyes of neuroscientist Antonio Damasio. It starts with a

general explanation of homeostasis and how the understanding of physiological regulation evolved throughout the years, with Hippocrates, Claude Bernard, and Walter Cannon, culminating in Damasio's Homeostasis Theory. The main difference between these traditional views on homeostasis and Damasio's is the addition of homeostatic feelings that can be conscious on top of the non-conscious forms of physiological control. So the main addition Damasio made to homeostasis theories is feelings. We must comprehend homeostatic sensations and how they work since they can begin to act as homeostatic guides.

It is becoming increasingly clear in neuroscience that the body's homeostasis and emotional response are relevant to our brain's functioning but difficult to incorporate into the design domains; therefore, this work presents potential as a path of research inquiry. This paper suggests that design might serve as an illustration of such a controlling mechanism. It raises questions such as: how the Theory of Homeostasis might contribute to understanding perception in design? To what extent might design be seen as an extension of ourselves, acting as psychic stabilizers or destabilizers? How might design play a role in the concept of homeostasis or allostasis? Neuroscience is beginning to show the importance of the body's homeostasis and emotions; however, applying this knowledge to design domains is challenging. This essay provides a chance to conduct the study. Understanding how homeostasis affects the built environment can be insightful for design thinking.

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