Constructing Our Niches: The Application of Evolutionary Theory to the Architecture, Engineering, and Construction (AEC) Industry

Author: Marcel J. Harmon

www.evolution-institute.org
# Table of Contents

<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>03</td>
<td>About Marcel J. Harmon</td>
</tr>
<tr>
<td>04</td>
<td>About BranchPattern</td>
</tr>
<tr>
<td>05</td>
<td>How Evolutionary Theory Is Useful for the Building Industry</td>
</tr>
<tr>
<td>11</td>
<td>Evolution’s Relevance to Modern Human Society</td>
</tr>
<tr>
<td>18</td>
<td>Introducing the Importance of Cooperation and Ultimate Vs. Proximate Design Features</td>
</tr>
<tr>
<td>23</td>
<td>The Misalignment of Ultimate Design Features With Their Proximate Manifestations</td>
</tr>
<tr>
<td>29</td>
<td>Constructing Our Niches: Exploring the Relevant Ultimate Design Features</td>
</tr>
<tr>
<td>41</td>
<td>The Ultimate/Proximate Relationship Relative to Codes and Standards</td>
</tr>
<tr>
<td>45</td>
<td>The Ultimate/Proximate Relationship Relative to Planning, Design, Construction, and Operations</td>
</tr>
<tr>
<td>55</td>
<td>References</td>
</tr>
</tbody>
</table>
About Marcel J. Harmon

Marcel J. Harmon, a licensed professional engineer and anthropologist, received his Ph.D. in Anthropology from the University of New Mexico. He currently co-leads the Research & Development team at BranchPattern, a building consultancy dedicated to improving life through better built environments. The primary mission of the team is to provide a research/evidence-based approach for aligning design intent with occupant and organizational needs. Over the years Marcel’s academic and professional focus have included applications of evolutionary theory to understanding past and contemporary societies and the reciprocal relationships between people and their built environments. In his current role, Marcel leads research projects designed to provide insights relative to specific client questions. He engages building occupants, gathering their stories and personal narratives, to ensure that projects better account for occupant’s wants and needs. He also quantifies the built environment’s impact on occupant productivity/performance and health, as well as the occupant’s impact on building performance. Marcel uses this understanding to inform on the process from early programming through post occupancy evaluations, and encourage longer term, prosocial decision making during the design/construction process.
About BranchPattern

People are at the core of everything the team at BranchPattern thinks, creates and does. This firm is a building consultancy dedicated to creating better built environments through many interwoven specialisms. Their beliefs are rooted in nature which has taught them that true sustainability sits at the intersection of human experience and environmental stewardship.

At BranchPattern, human experience influences design, not the other way around. Their team of experts, drawn from the fields of engineering, architecture, social science, testing and analytics, are dedicated to sustaining communities and propelling them forward through energy-efficient building designs that improve the built and natural environments — inside and out.

The name BranchPattern is inspired by the natural environment. “Branch patterns” are the building blocks of natural systems. Humanity is innately drawn to these elegant and efficient fractals. This deep connection is represented throughout mankind’s history of science, art, engineering and architecture. Looking closely, one sees that the buildings and infrastructure are full of fractals and branching patterns.

Through the study of patterns found in nature and human behavior, the team is better able to understand the inherent relationship between the two. Understanding the natural sciences and incorporating them into the built environment satisfies psychological and physical needs and reduces ecological footprints.
How Evolutionary Theory Is Useful for the Building Industry

Whether we’re talking about education, healthcare, manufacturing, NGO’s or the corporate world, there seems to be no lack of expertise, ideas, or opinions on how the organizations working in these or other sectors should be structured, nor how the environments housing them should be designed and operated. What does appear to be lacking is any cohesive framework for a) formulating such organizational structures and their physical environments, and b) evaluating their effectiveness to make improvements moving forward.

I believe that evolutionary theory provides such a framework. For those unfamiliar with the contemporary theoretical perspectives of cultural evolution or multi-level selection, likely most of the building/construction industry at this point, reactions may range from blank stares to downright skepticism. While some may be unable to fully articulate their skepticism, the following question probably captures it for many. Haven’t humans evolved to the point where the forces of evolution are irrelevant to the complex, fast-paced inner workings of modern human societies? To which I and many others would answer – No. Evolutionary theory is very applicable to contemporary humans and our social/cultural worlds, including the world of the building/construction industry.

In part this is because the human behaviors and intellectual traditions of design and construction, as well as the resulting built environments themselves, are part of the human phenotype – an individual’s set of observable characteristics (including behavior and the products of behavior) that result from the interaction of its genotype with its environment. They are part of our collective toolkit for adapting to the larger social/cultural and physical environments we live within, individually and as members of nested groups of ever increasing size.

Understanding this, as well as how evolutionary forces play out from the level of the gene to the level of society, allows us to more deliberately create environments, or niches, that benefit everyone in the short and long term, as opposed to doing so more by accident. It will contribute to designing, building and operating more sustainable and regenerative built environments that better meet the productivity and health needs of building occupants and organizations, as well as minimize, and even reverse, the built environment’s contributions to climate change. I believe it will benefit building occupants, owners and society as a whole. But I’m getting ahead of myself.

This is the first essay in a series demonstrating why this is the case and laying out how it can be done. But you may be wondering why I’m the person for this task. What is it about my background, interests and expertise that qualify me to lay out the use of evolutionary principles in the building/construction industry? Fair question. So, let’s answer that here before delving into the details in future essays.

My intellectual interests have long meandered among engineering, the physical sciences,
social sciences and history. As a kid I bounced from interest to interest – astronomy, physics, chemistry, biology, history, and the like. By the time I entered Kansas State University as a freshman in the fall of 1986, I had finally landed on obtaining dual degrees in Architectural Engineering and Anthropology (with an Archaeological focus).

Anthropology and archaeology certainly provide a broader context within which to look at how we construct, maintain, and operate our built environments. But at the time I thought my ultimate goal was to bring aspects of engineering into archaeology. Throughout its history, archaeology has borrowed from other disciplines to help it survey, excavate and interpret the archaeological record. I hoped I could eventually offer methods and bodies of knowledge from the worlds of engineering and the building/construction industry, like what others have done.

With that in mind, I finished my dual degrees. I worked as an engineer to gain more technical experience relative to the built environment, designing mechanical, electrical/lighting and plumbing systems for a variety of project types. My wife and I also moved to Albuquerque, NM to establish residence with the intent of applying to the University of New Mexico’s (UNM) graduate program in Anthropology. And finally, in the fall of 1996, while still working as an engineer, I entered the program as a graduate student.

I started out following my original goal. I worked with UNM’s mechanical engineering department to conduct impact analyses on replicated obsidian prismatic blades to determine their use-life in battle. I used lighting design software to assess the impact daylight access may have had when prehistoric Puebloans laid out the locations of multiple mealing bins within a room or pit structure. I borrowed space syntax methodologies to examine similarities between European longhouses and megalithic monuments that have been used to support various theories of European Neolithic interactions. And I made use of close-range photogrammetry and ground penetrating radar at archaeological sites in southern New Mexico and Northern Mexico.

But along the way I met a professor, Dr. Robert (Bob) D. Leonard, who would eventually become my dissertation chair, mentor and friend, and in the process changed the way I viewed the world. He introduced me to one evolutionary framework within anthropology synthesized in Robert Dunnell’s’ article entitled Evolutionary Theory and Archaeology. This application of evolutionary theory has been labeled at times Selectionism, Evolutionary Archaeology, and Darwinian Archaeology. It seeks to explain the variation archaeologists find in the material record using evolutionary theory.

Such an evolutionary framework applied to humans rests on five assumptions that are spelled out by Leonard[207]:

1. Humans are life forms.
2. Natural selection operates on phenotypes, making evolution in part a phenotypic phenomenon.
3. Behavior is part of the human phenotype, and it is transmitted partially through learning.
4. Technology is the product of human behavior, and consequently a component of the human phenotype.
5. The differential persistence of behavior will be reflected by the differential replication of technology through time.

And to clarify for those unfamiliar with some of these terms and concepts, the phenotype refers to all of the characteristics of an organism (or group of organisms) that “... include biological
features, such as skin color, height, muscle strength, basic behaviors, etc., as well as cultural features such as tools, artifacts, dwellings, institutions, etc. that are the results of behaviors. Given this, we can use Darwinian evolutionary theory to not only understand human biological change, but also human cultural change and transmission.

My understanding was deepened further with my introduction, through Sober and Wilson and Wilson among others, to a branch of evolutionary theory known as multi-level selection, or MLS. For those unfamiliar, MLS provides a framework in which natural selection and other evolutionary forces operate at all levels simultaneously – genes, cells, individuals, and groups of individuals. Sometimes environmental and social/cultural conditions are right for the evolutionary forces to be stronger at the level of the individual; sometimes these forces are stronger at the group level, resulting in highly cohesive groups. Uniformity among group members, high levels of cooperation, and functional integration become the hallmarks of successful groups. Change resulting from evolutionary forces may also be quite rapid if selection is operating at the level of the group.

Thinking back to my -youth spent farming in southcentral Kansas, this view of human culture, including our tools and associated behaviors, as part of the human phenotype and subject to the forces of evolution made sense. Terraces are a farming adaptation, a behavioral strategy, for maximizing water retention in soils while minimizing water erosion. In response to the droughts and Dust Bowl era of the Dirty Thirties, more sustainable farming practices, including the use of terraces, were promoted throughout the plains, and my grandfather, James M. Harmon, was one of the first farmers to build them in the community of Penalosa, KS.

My grandfather, along with other area farmers, changed their farming behavior to adapt to changing environmental conditions. This new behavioral variant proved beneficial from an evolutionary perspective – it helped individual family farming units recover and conserve their farmland (with some governmental assistance), also benefiting the small, rural communities they were a part of. And the practice spread among the farming community populations as restoring and conserving soil, the life blood of these communities, became associated with the practice of terracing, or so goes the story I heard from grandfather (minus the references to evolutionary theory).

Essentially evolutionary forces, likely operating at some combination of the levels of the individual family farm, their larger communities, and potentially up to the level of the nation/state, selected for a specific farming behavioral trait (terracing), in a relatively rapid manner in response to ultimately a relatively rapid, drastic, physical

Uniformity among group members, high levels of cooperation, and functional integration become the hallmarks of successful groups.
environmental change. Once Bob Leonard (and other scholars) had given me these evolutionary glasses to view the social/cultural world around me I couldn’t take them off. I couldn’t un-see the world from an evolutionary perspective, and it led to my dissertation research.9,13

The techniques, tools, and intellectual traditions of design and construction are all part of the human phenotype and subject to the forces of evolution. Therefore, they can be studied relative to the selective advantage they offer the individuals and human groups that use them. In addition, intellectual traditions are essentially chains of replicated information, formed as a result of “…transmission directly from individual to individual (through some type of teaching and learning relationship) or indirectly from individual to individual (either by imitating a person’s actions or reverse engineering a finished product or concept).”9(p202) As such, phylogenetic analysis methods developed to study biological lineages can also be used to study cultural lineages (intellectual traditions) via an examination of the transmission of their traits across space and time, as well as the uniformity of those traits within a given intellectual tradition. e.g. 8,14,15,16,17,18

With this in mind, I attempted to obtain a better understanding of the degree of centralization within the Casas Grandes region of Northern Mexico during the Medio period (A.D. 1200 – 1450), by examining the regional manifestation of the Native American rubber ballgame. The ballgame, which ranged from northern South America to the American Southwest in various forms, is generally considered to have played an important political, economic and religious role in the societies in which it was found. Using both phylogenetic analysis and seriation, I examined the transmission of ballcourt characteristics across the region (spatially and temporally). These characteristics encompassed aspects of design/construction, gameplay, and the court’s relationship to its overall settlement.

By interpreting the transmission of these ballgame and court characteristics within a multilevel selection theoretical framework, I was able to reconstruct the region’s apparent three ballgame intellectual traditions, as well as reach some conclusions regarding the nature of the region’s centralization, centered on the site of Paquimé. It was, I believe, an important use of evolutionary theory to better understand the social, religious and political makeup of a past society. And if it could be used to understand past societies, why not contemporary societies?

As I neared the completion of my dissertation, the confluence of a few factors caused me to rethink my post graduate career. During graduate school I continued working as an engineer, and I began to see the potential benefits of applying aspects of anthropology and evolutionary theory to the design, operations and evaluations of our built environments. I found that a contextual understanding of occupant needs and behaviors was often a secondary concern of designers, facility managers and building owners compared to such things as construction costs, building operations and maintenance costs, and design aesthetics. Frequent conversations with Bob Leonard focused on how anthropological methods, such as ethnography, various statistical analyses methods and an evolutionary interpretive framework could better account for those contextual needs and behaviors, as well as justify a greater level of focus on them. With a desire to move back to Kansas to be closer to family, consulting work appeared the easier path than academia to make that happen. After a relatively short-lived attempt
at running our own consulting business (Human Inquiry), made more difficult by being located in different states (Iowa and Kansas), Bob Leonard and I decided to dissolve the business and part ways professionally. At that point I was fortunate to find a high performance consulting engineering firm, BranchPattern, who shared my vision of a building/construction industry that a) more systematically conducts post occupancy evaluations, b) provides a greater focus on the occupants’ wants, needs, productivity and health (including a recognition of the influence of our evolutionary history), c) incorporates social science methodologies as part of the programming through post-occupancy process, and d) recognizes all three of these impact a facility’s successful incorporation of sustainable or regenerative design strategies and ultimately the amount of greenhouse gas (GHG) emissions it contributes to our atmosphere.

And so, I joined BranchPattern in 2007 to help ensure the occupants’ perspectives are accounted for from early planning through post occupancy. In my current position, I gather occupant stories and personal narratives to help ensure projects account for their contextual wants and needs. I quantitatively estimate the built environment’s impact on occupant productivity/performance and health, as well as the occupant’s impact on building performance. We use this understanding to influence and inform the decisions made during the programming/planning process, help develop owner project requirements (OPR) documents, conduct design reviews during enhanced commissioning, help assess facilities post occupancy, and conduct research.

Over the last decade evolutionary theory, and the evolutionary history of our species, have influenced the recommendations I’ve made and some of the research I’ve conducted. But my explicit reference to evolutionary theory, while appearing in some of my writings, has been fairly limited on a day-to-day, project-by-project basis.
Frankly, the reactions from many in the building/construction industry whom I’ve had such conversations with over the years have ranged from blank stares to slightly hostile resistance. The relevance of evolutionary theory, particularly the much less well known multilevel selection theory, to contemporary human society is not widely understood or accepted.

And so, my focus over the last decade has been more on increasing a) the frequency of pre- and post-occupancy evaluations, b) a focus on the occupant, and c) the use of anthropological and social science methodologies. Such methodologies are used to better understand a) the contextual wants and needs of the building/occupant organism, and b) how to structure the environment to meet those wants and needs – how to best build their niches. We’ve made progress in generating greater acceptance among building owners and those who work in the industry. While it’s been slow, the rate of acceptance has increased over the last few years with the growing recognition of the impact of occupant productivity and health on the building owner and/or organization’s bottom line. The creation of the new WELL Building Standard™ with its focus on the occupant, has also contributed to this growing acceptance.

Now the stage has been set to more formally operate within an MLS framework. The contextual understanding of the building/occupant organism is the starting point for understanding how adaptive aspects of our physically constructed and social/cultural environments, or niches, are relative to individual, organizational or societal needs. It’s the starting point for understanding how those nested levels of needs are in or out of alignment with a) one another, b) the physical environment’s operational capabilities, and c) organizational policies and procedures.

And ultimately, it’s the starting point for determining the environmental changes required to optimize alignment and maximize positive impacts on productivity and health, as well as aspects of sustainability.

In the next six essays, I lay out in more detail why evolutionary theory, and MLS in particular, is applicable to the building/construction industry and how it can be applied to more effectively construct our niches. To do this, I draw on my own experience and expertise, as well as that of other researchers, industry professionals and applied evolutionists.
Evolution’s Relevance to Modern Human Society

In the previous essay, I introduced the idea that operating deliberately within an evolutionary theoretical framework offers benefits to the building/construction industry and justified why I was the person suited for making this argument. Now it’s time to wade into the evolutionary pool, starting with a more thorough discussion of why evolutionary theory is applicable to contemporary humans and our social/cultural worlds.

As I previously discussed, this applicability rests on the following five assumptions that are spelled out by Leonard9(p72):

1. Humans are life forms.
2. Natural selection operates on phenotypes, making evolution in part a phenotypic phenomenon.
3. Behavior is part of the human phenotype, and it is transmitted partially through learning.
4. Technology [along with other aspects of our social/cultural worlds] is the product of human behavior, and consequently a component of the human phenotype.
5. The differential persistence of behavior will be reflected by the differential replication of technology [or other aspects of culture] through time [and/or across space].

Again, the phenotype refers to all of the characteristics of an organism (or group of organisms) that “… include biological features, such as skin color, height, muscle strength, basic behaviors, etc., as well as cultural features such as tools, artifacts, dwellings, institutions, etc. that are the results of behaviors2,3,4,5,6,7,8,9(p204).

The phenotype for individuals results from the interaction of that individual’s genes with the surrounding physical and social environment. For cohesive groups, it results from the interaction of the group’s individual members with the surrounding physical and social environment. The transmission of this phenotypic variation occurs biologically (genetic inheritance via sexual or asexual reproduction) as well as culturally (information inheritance via teaching/learning, imitation, reverse engineering, etc.).

This means that human behaviors, the physical objects we create and use (such as the built environment), and their associated intellectual traditions (including those of the design/construction industry), are part of our collective toolkit for adapting to the larger social/cultural and physical environments we live within, individually and as members of nested groups of ever-increasing size. Given this, we can use Darwinian evolutionary theory to not only understand human biological change, but also human cultural change and transmission.

To illustrate this, let’s examine the use of forced air as the dominant modern method in the U.S. to heat and cool buildings. In such systems, air is used as the primary medium to transfer heat energy, either into a space through the introduction of warmer air, or away from a space through the introduction of cooler air (though the manipulation of humidity levels also plays a role in this). Yet air is a relatively
poor medium to use for capturing and moving heat – it’s a far better insulator. Water, also used to capture and transfer heat around in modern HVAC systems, is 832 times denser than air, and can therefore do this quite a bit more efficiently per unit volume than air can. Air’s specific heat value (the amount of energy required to raise a unit volume of material by one degree, an indicator of a material’s ability to capture and move energy) is just under 25% of the value for water.\textsuperscript{19(p72)}

Nor are air-based systems as effective at maintaining thermal comfort compared to systems that use some combination of radiant heating/cooling, low-velocity underfloor air distribution and natural ventilation. In part, this is because in most situations only 27.5% of the human body’s exchange of heat energy with its surrounding environment results from convective transfer, that is the transfer of energy via the movement of molecules within a fluid or gas (i.e., air coming into contact with building occupants). Whereas radiant transfer, via the absorption of electromagnetic waves from a source at a greater energy intensity level (such as a radiator, thermally active building surface, or another warmer human body), accounts for the bulk of this exchange at 47.5%. The other 27% results from exhalation and a few other physiological processes.

It is true that conduction, heat transfer via the direct contact of objects, can dominate all other modes of heat transfer – think back to wrapping your hands around a hot cup of coffee or walking on the cold tile of a bathroom floor with bare feet first thing in the morning. However, conduction is a much less common occurrence and certainly not a primary method used to maintain thermal comfort in the built environment.\textsuperscript{19(pp68-70)}

Thermal comfort is dependent on other factors as well, such as variation in the insulative properties of clothing, occupant activity levels, metabolism rates, the degree of personal temperature and ventilation control, expectations, and connections to nature, to name a few. But these factors don’t change the basic limitations of air-based heating/cooling systems. Which begs the question, how did these comparatively inefficient and ineffective systems out replicate other forms of heating and cooling in the U.S.? Why did the behavior that produced this technology have greater persistence than the behavior producing other technologies, such as radiant based heating or cooling? What was it about air-based systems that provided a greater selective advantage from an evolutionary perspective over other means of heating and cooling? Perhaps more importantly, who was that advantage provided to?

Looking at just the ability to control the rate of heat gain or loss from one’s own body, or that of your children, grandchildren, etc., then behavioral/technological adaptations that allow you to control this rate of change through such things as clothing, fire pits, fireplaces, fans and centralized heating/cooling systems do offer a selective advantage to individuals and their genes. The more extreme the environmental temperature, the greater the advantage of being able to control one’s rate of heat gain or loss. Such control allows us to minimize our exposure to temperature extremes that result in death or the physiological stress resulting from prolonged or chronic thermal discomfort, which can shorten life expectancy or even lead to emotional distress.\textsuperscript{20,21,22,23,24,25}

One’s ability to survive long enough to reproduce and the rate of survival of one’s offspring are then positively impacted by this general behavioral/technological adaptation. While certainly critical for our long distant hunter-gatherer ancestors, this part of our
phenotypic toolkit still increases our relative fitness to this day. It positively impacts our species’ rate of reproduction relative to not having this adaptation. And over time, more fit technologies out replicate, or replace, less fit technologies that are less effective in increasing our reproductive fitness (O’Brien and Lyman 2000), such as the eventual supplanting of fireplaces by central heating systems as the dominant means of heating during the 19th and 20th centuries.

However, fitness isn’t only defined with respect to the reproductive success of individuals or our genes. Recall from the first essay in the series that evolutionary forces can operate at multiple levels simultaneously – genes, cells, individuals, and groups of individuals – see the last for a summary of the basic tenets of MLS Theory. The ability to control the rate of heat gain or loss would also have increased the relative fitness of the nuclear family units or larger kinship groups of our hunter/gatherer ancestors. It also increases the fitness of contemporary businesses relative to other competing organizations. All else being equal, the more employees can effectively control their rate of heat gain/loss according to personal preferences, the more thermally comfortable and subsequently more productive they are. Let’s now explore how these relative fitness benefits at varying levels of selection likely influenced the development of HVAC systems in North America.

Over the course of the eighteenth and nineteenth centuries, the needs of increasingly large and complex industrial, hospital and prison facilities was a primary driver for the development of heating and ventilation technology. These facilities needed to address the presence of foul air as well as heat larger volumes of space containing larger numbers of people. As a result, the primarily radiant based fireplace of the eighteenth century evolved into the centralized, mechanically powered convective based heating and ventilation systems of the late nineteenth century. At the time, coupling convective heating with ventilation was the most effective way to meet both needs. Fire was originally used to generate the convective currents of air in these early ventilation systems, and so it was easy to couple the functions of convective
heating and ventilation together into one system. It also made sense to continue this coupling as heating and ventilation systems further developed. By the end of the nineteenth century, artificial heating and ventilation were fully integrated and centralized within the same distribution system.

The 19th century also saw some early attempts at artificial cooling, such as more elaborate uses of ice to cool moving air as well as the introduction of early compressors. But it was the thermal comfort of industrial machinery that really drove the development of artificial cooling during the late nineteenth and early twentieth centuries. As industrial equipment increased in size and number, there was a growing need to both dissipate the heat generated by this equipment, as well as more tightly control the humidity levels within industrial/manufacturing spaces, such as printing and textile facilities. Enter Wills Haviland Carrier, the Father of Air Conditioning.

Building on previous research and engineering applications of air conditioning in manufacturing facilities, Carrier developed his psychrometric chart and formulae which quantified the relationship between temperature, humidity and dew point. Contemporaries of Carrier independently formulated similar diagrams and formulas, but partially because of his ambition and marketing abilities, Carrier’s chart, formula, and underlying principals ultimately formed the basis of contemporary air conditioning engineering.

Those manufacturing companies incorporating air conditioning for their industrial equipment increased their production rates and efficiencies. It put them at an advantage – it increased their relative fitness – compared to other manufacturers who didn’t adopt air conditioning or were slower to do so. And the fact that air conditioning could make use of the same centralized heating/ventilation distribution systems already being used in manufacturing facilities made it that much easier. Evolutionary forces operating at a group level, namely manufacturing companies, essentially selected for air conditioning as a phenotypic adaptation of manufacturers. This isn’t to say that the selective advantages to shareholders or individual employees wasn’t a factor as well, but the competitive economic environment that existed likely resulted in the level of selection stronger at the group than that of the individual.

Cooling equipment gave way to cooling people as awareness grew. With the ability to artificially cool environments now actually available, the comfort provided in hot and humid conditions (along with the decreased health risks during temperature extremes) coupled with the aggressive marketing from Carrier and other early HVAC system manufacturers, artificial cooling was initially seen as a symbol of status before eventually becoming the norm.

The demand for commercial and multi-family/single-family residential applications of forced air HVAC systems (including window AC units) steadily grew over the early to mid-20th century. These early HVAC systems along with electric lighting also allowed developers, builders, and business owners to free themselves from the constraints imposed by the need to passively heat/cool, ventilate and daylight spaces. Building orientations and configurations no longer had to maximize cross-ventilation, passive solar heating or daylight penetration. This reduction in contextual environmental constraints, along with the desire of
The more extreme the environmental temperature, the greater the advantage of being able to control one’s rate of heat gain or loss.

- The constraints to subsequent technological developments imposed by a) the coupling of convective heating and ventilation during the 18th and 19th centuries and b) the need to more tightly control environmental temperature and humidity for manufacturing equipment during the late 19th and early 20th centuries, and

- The financial benefits and increased relative fitness provided to Carrier and other forced air HVAC manufacturers through the aggressive promotion of forced air HVAC systems.

The constraints mentioned above in the second bullet point are part of the social/cultural and physical environment that evolutionary forces, such as natural selection, operate within. The conditions of the environment at any given time limit the direction that evolution will proceed forward. While some combination of radiant heating/cooling and natural/forced air ventilation would best address the human physiological and psychological processes relevant to human comfort, the technology and engineering knowledge readily available at the time, combined with the other two factors listed above, made the path to dominance significantly easier for forced air systems in the U.S.

The uniformity provided by a single dominant type of HVAC system played a role in this as well. In general, uniformity imposed on group members (such as that through social/cultural norms) enhances the cohesiveness, cooperation and functional integration of groups. Norms (including formal laws, regulations, standards, etc.) help create common experiences and expectations among group
members, binding them together. As a result, they help suppress within-group selection among group members that can disrupt the cohesiveness of groups, ensuring that between group forces dominate. During the late 19th and early 20th centuries, the standardization of materials, systems, and building configurations increased the uniformity within manufacturers, designers, builders and business owners. Even if a given design solution wasn't the most optimal (such as forced air compared to radiant relative to thermal comfort), the uniformity offered by standardizing on a solution in and of itself provided a selective advantage to these organizations, the building/construction industry, and society at large.

In fact, at the level of the nation-state, particularly one like the U.S. with diverse social/cultural subgroups, such technological standardizations that cut across these varying subgroups help unify the larger nation-state. And one could argue that developers and building owners who lagged incorporating HVAC systems into their facilities would have been outcompeted by their competitors, potentially going out of business. The new building/construction environment at the time, partially defined by HVAC use, would have selected against those developers and builders.

For the purposes of this essay, I’ve simplified the exercise of framing the U.S.’s history of HVAC within an evolutionary theoretical framework. There are obviously more details and nuances within the history itself, as well as with the evolutionary applications. Such specifics could be fleshed out in more detailed overviews and studies. One of many potential examples would be the use of phylogenetic analysis (or cladistics), along with other statistical methods, to systematically examine the development and distribution of HVAC system characteristics from the nineteenth through twentieth centuries, across the U.S., and across various sectors (residential, commercial, healthcare, etc.). This would provide a more detailed picture of the developing uniformity of HVAC systems around air-based technology over this time, and across the U.S. and various sectors, clarifying the overview presented above.

And the story obviously doesn’t end here. While forced air systems still dominate in the U.S., that dominance is waning, driven in part through such things as the energy crisis of the 1970’s, recognition of the threat of anthropogenic (human-caused) climate change, the phenomenon of sick building syndrome, and the proliferation of sustainable and wellness certification systems. The selective environment has changed.

“Hybrid” systems that integrate water as a means of transferring heat (and even beam heat into space), passive heating/cooling methods, and systems that use some combination of radiant heating/cooling, low-velocity underfloor air distribution and natural ventilation are becoming more the norm. There is greater recognition among decision makers that energy consumption, greenhouse gas (GHG) emissions, the impacts of thermal discomfort, and other aspects of sustainability and health/productivity have an impact on their bottom line. And with regards to climate change, we’re recognizing the need for more sustainable and regenerative built environments that better meet the productivity and health needs of building occupants and organizations, as well as minimize, and even reverse, the built environment’s contributions to GHG emissions.

The relative selective advantage offered by increased thermal comfort, decreased energy consumption, and decreased GHG emissions is now enough to overcome the advantage offered by the previous industry standardization on forced air systems. The
baseline is no longer a lack of mechanical heating/cooling or just cooling. Competition among building systems, the firms who design, install and manufacturer them, as well as the organizations who use them, is now relative to the quality of heating/cooling provided and energy consumed, not the use of heating/cooling vs. no or limited heating/cooling. Changes in the physical and social/cultural environments are selecting for changes in the types of heating/cooling systems we manufacture and install in our built environments. Though the Trump administration, segments of the fossil fuel industry, as well as other organizations like the Heartland Institute, continue in their efforts to limit or reverse some of these changes in the social/cultural environment. Nor does natural selection care if we’re deliberately taking actions with evolutionary consequences in mind. The ability to understand the consequences of our actions, policies, etc., from an evolutionary perspective offers significant potential to help guide better decision making moving forward. It gives us an added selective advantage, but only if we recognize this and choose to act on it. During the early 20th century, if we had better understood anthropogenic climate change, the determinants of human thermal comfort, and the impacts of discomfort on productivity and health, then the history of HVAC in the U.S. might have been different. In the next essay, I begin exploring how to do this with a discussion of Elinor Ostrom’s Nobel Prize-winning research on avoiding the tragedy of the commons phenomenon.
In the last essay, I demonstrated some of the insights evolutionary theory can provide in understanding our contemporary social/cultural worlds, using the history of heating, ventilation, and air conditioning (HVAC) in the U.S. as an example. Now I’ll begin discussing how evolutionary theory can guide decision-making and the development of policy that benefits more of us collectively, for longer periods of time. Such collective, sustainable behavior is partially dependent on maintaining higher levels of cooperation among those involved, from the boardroom to the global stage.

In the building/construction industry, the success of the design/construction process, the operations of our facilities and the general functioning of the organizations housed within these facilities all hinge to a degree on achieving cooperation among the relevant parties involved. For example, a significant amount of cooperation is needed among the commissioning agent, design/construction team members and the building owner during the peer review process of enhanced commissioning. Cooperation is needed to ensure the owner’s project requirements and building occupant needs are met while also minimizing negative environmental impacts and meeting budget constraints.

Elinor Ostrom, a political scientist and 2009 recipient of the Nobel Prize for economics, identified eight design features that are the hallmarks of groups able to successfully cooperate. Ostrom’s work originally focused on understanding how groups avoid the tragedy of the commons phenomenon by increasing their ability to cooperate in the shared objective of managing common pool resources. These are resources important for the long-term viability of the larger group but are at risk of inequitable access, overuse and/or depletion by individuals and smaller groups. The tragedy occurs when those resources are over-exploited to the shorter-term benefit of individuals or smaller groups at the expense of the larger group (usually over the longer term).

Below is a list of the design features Ostrom found to be necessary in some form for cooperation among group members to achieve a shared objective (whether that’s avoiding the tragedy of the commons or another objective). The specific wording is taken directly from Wilson et al. but see Wilson et al. for a more thorough discussion.

1. A strong group identity, including understanding and agreeing with the group’s purpose.
2. Benefits proportional to costs, so that the work does not fall unfairly on some individuals and unearned benefits on others.
3. Consensus decision-making, since most people dislike being told what to do but will work hard to achieve their own goals.
4. Low-cost monitoring, so that lapses of cooperation can be easily detected.
5. Graduated sanctions to correct misbehaviors, which begin with friendly reminders and escalate only as needed.
6. Conflict resolution that is fast and perceived as fair by group members.
7. Sufficient autonomy for the group to make its own decisions without interference from other groups.
8. Relations among groups that embody the same principles as the relations among individuals within the group.

It’s important to point out that these design features are ultimate in nature, in that they’re functional to our species, having solidified as adaptive in the smaller scale human societies that have dominated most of human history. They’re still functional in our modern, larger societies, though some nuances relative to a multi-level selection framework are required. Successful implementations of these design features, however, will look different in different social/cultural and physical environmental contexts. They will have proximate manifestations contingent on the relevant local contexts.

Let’s further explore this by looking at the process of integrated design. This holistic process involves bringing all the relevant key stakeholders of a project together in collaboration from the earliest phases of planning through the eventual occupancy and use of the facility. Ideally everyone provides their perspectives and expertise in the establishment of the project’s vision and goals, determining how to reach those goals, enacting those goals, and verifying the goals have been met. The degree of involvement of any specific stakeholder will vary throughout the course of the project, but they should be aware of how the process unfolds and provide input when warranted. For example, the bulk of the general contractor’s (GC’s) effort occurs during construction, but the GC’s perspective and varying degrees of involvement is still needed throughout the process to help ensure success. And in fact, when the Construction Manager at Risk (CMAR) method of project delivery is used (a specific proximate manifestation of an integrated design process), the GC is more heavily involved during the planning and design phases.

Those working in the building/construction industry would recognize that Ostrom’s first design feature, a strong group identity, including understanding and agreeing with the group’s purpose, is critical to achieving a successfully integrated design process. Bringing the key stakeholders together early, from the architect and contractor, to building owner and facility manager, and to the occupants themselves, is critical for establishing buy-in of the project vision, scope and goals, as well as binding the group together in pursuit of these common goals. The proximate manifestation of this design feature will vary, though, depending on many factors.

For example, the number of key stakeholders, their socio/economic and educational backgrounds, the types of disciplinary expertise represented, the project delivery method, and the scope of the project (small renovation to a new facility) will all impact how a strong group identity is established and maintained. The more disparate the above factors, the greater the effort required to generate understanding among the different perspectives, needs and values, and then coalesce and remain united in pursuit of a single vision and set of goals. If a particular stakeholder or stakeholder group feels their perspective was ignored during the early meetings, planning charrettes, interviews, etc., the cohesiveness of the overall project group may be negatively impacted, affecting the quality of the integrated design process and eventual success of the project.
Ostrom’s fourth design feature, low-cost monitoring, so that lapses of cooperation can be easily detected (further ensuring that cooperation takes place), can take many proximate forms throughout an integrated design process. One form is the owner’s project requirements (OPR) document, which details the project’s goals, performance requirements, and success criteria. Ideally established at the beginning of planning, this document holds everyone accountable to the project’s vision and goals throughout the design/construction process. Any additions, modifications, or deletions to the design that impact the vision and goals require that the OPR be updated, and the reasons for those changes documented and dated. One of the reasons it’s effective as a form of monitoring is that it provides transparency of 1) the nature of the project’s vision and goals, 2) design or construction changes that impact the vision and goals, 3) who instigated the changes, and 4) why the changes were made and what impacts they’re estimated to have.

BranchPattern (the firm I work for) previously provided commissioning services for a banking client building a new headquarters. As part of the services provided, we worked with our client and the design/construction team to develop the OPR document early in the process. One of OPR’s requirements (listed below) agreed to by every stakeholder set a minimum ventilation rate at 30% above the minimum recommended by ASHRAE 62.1 (a ventilation standard produced by the American Society of Heating, Refrigerating and Air-Conditioning Engineers):

- **Target LEED EQ cr2 (ASHRAE 62.1 + 30%)** for IAQ [indoor air quality] pertaining to existing buildings in terms of ventilation rate and outside air requirements. The design/construction team will consider the impacts of higher ventilation rates relative to design and operational budgets.

Requiring a ventilation rate above 62.1 was driven by a growing body of research indicating that CO₂ levels impact cognitive function at lower levels than previously thought, impacting the productivity and performance of occupants. In fact, some of the more recent research recommends maximum interior CO₂ levels significantly closer to the levels found in exterior environments. That’s not surprising, considering our physiologies and psychologies evolved in predominantly exterior environments.

Throughout the design/construction process, the OPR document and the transparency associated with making changes to that document contributed to maintaining the OPR’s goals and specific requirements by helping to hold everyone accountable. Increased ventilation comes at a cost through potentially increased sizes in mechanical equipment and ductwork (and therefore increased construction costs), as well as increased operational (utility) costs. But the resulting...
increases in productivity/performance benefits the occupants, as well as the organizations they belong to.

However, these benefits can be harder to quantify and won’t show up until after the building is occupied. In the pressure cooker that sometimes develops towards the end of design, as deadlines loom, budgets tighten, and the overall group identity and unity of purpose is stressed, such design goals are often value-engineered out of a project without accountability measures in place like an OPR.

The final essay in the series explores the application of evolutionary theory, and specifically Ostrom’s design features, to the planning, design, construction and operations processes in more detail. For now, let’s return to how well the environments we create function for working, living, playing and learning in. I propose that with regards to the design, construction and operation of our built environments, the nature of Ostrom’s design features and other ultimate design principles, and their most appropriate proximate manifestations, depend on understanding the following:

1. How the physiological and psychological constraints that result from our evolutionary history, in turn, have shaped our individual and group needs, behaviors and decision making in various modern group settings. e.g. 49,50

2. How our evolutionary history spent primarily as hunter/gatherers has shaped the social/cultural tools we have available for living and interacting in group settings. e.g. 26,50

3. How the appropriate proximate manifestations of these ultimate design principles are determined by a) who the specific individuals and groups are (and how they’re nested together), e.g. 26,47,51 b) what their physiological and psychological needs consist of, e.g. 26,49,51 and c) what their social/cultural and physical environments currently and/or need to consist of, e.g. 26,49,51

I’ve emphasized the physical environment because if it isn’t aligned with physiological and psychological needs or the social/cultural environment that’s been designed based on the proximate implementations of the relevant design principles, then the ability to cooperate in pursuit of shared objectives will be negatively impacted.

A second example will briefly illustrate how Ostrom’s design features and other functional design considerations were implemented in a very different setting—the Regents Academy, a school for at-risk 9th and 10th graders in Binghamton, New York.46 The design of the school program (housed within a larger high school) was informed by an evolutionary understanding of cooperation and learning. Ostrom’s design features were specifically addressed in the development of the program to help the Regents Academy group pursue the shared goal of improving student performance.

To address design features 1 (strong group identity) and 7 (autonomy), as well as help facilitate 4 (monitoring), 5 (graduated sanctions), and 6 (conflict resolution), the program was developed as a self-contained unit with its own principal, teachers/staff and physical location. These functional considerations were implemented in a proximate sense by assigning a number of adjacent rooms for the program and creating a schedule that kept the students largely isolated from the other students and programs occupying the same building. This helped provide a stronger group identity as well as a measure of autonomy for the program separate from the rest of the high school.

Bringing an awareness of evolutionary theory to the table, the designers of the
Regents Academy deliberately attempted to contextually align the physical environment’s capabilities with the requirements of these ultimate design features. They also recognized that the proximate implementation of these design features required constant monitoring to see if they were working and tweak them when necessary. The results by the end of the year were so successful that not only did the students outperform a comparison group of at-risk students in a randomized design, but they even performed on par with the average high school student in the school district.

For any design/construction project, it’s critical that the physical and social/cultural environment’s proximate manifestations be aligned with the requirements of the ultimate design features relevant to the project’s occupant, organizational and facility operational needs. Misalignment results in varying degrees of failure, and the next essay explores this in more detail.
The Misalignment of Ultimate Design Features With Their Proximate Manifestations

In the previous essay, I began exploring how evolutionary theory can guide cooperative decision making and the development of policy that benefits more of us collectively, for longer periods of time. In this essay, I build on these previous discussions to further explore how misalignment of the physical and social/cultural environment’s proximate manifestations with the relevant ultimate design features’ requirements results in varying degrees of failure. Specific real-world examples are one of the most effective ways to demonstrate this.

As a professional who frequently evaluates the building/occupant organism, I’ve seen how thermal comfort inequities across a building or campus undermine Ostrom’s design feature 1 (a strong group identity, including understanding and agreeing with the group’s purpose).\textsuperscript{45,46} Something I’ve commonly observed working for BranchPattern, is varying levels of thermal comfort and personal temperature control across any given pre-K – 16+ campus. The reasons are wide-ranging, consisting of everything from poorly designed or constructed building envelopes, to multiple spaces sharing a single thermostat (exacerbated when those spaces have different heating/cooling needs), to ignoring how the human body actually transfers heat (refer to the second essay in this series), to inadequately accounting for how variation in demographics (age, gender, clothing, etc.) impacts thermal comfort.

In situations where multiple classrooms or administrative offices share a single thermostat, or where teachers/staff share a single space, I have observed conflicts over thermostat control that range from small degrees of tension to open hostility. Passive-aggressive actions, such as the repeated adjustment of thermostats up or down in the absence of the other person, aren’t uncommon. Where multiple rooms are controlled by a single thermostat, the individual with the thermostat may lock their door when absent to keep the other person(s) from making adjustments. Some individuals avoided making thermostat adjustments for fear of negatively impacting others, or for fear of how others would react. Even when teachers/staff were willing to share control, the thermostat setting became another point of negotiation (sometimes multiple times a day) for teachers/staff who are already overworked, underpaid and stressed.

Here are a few survey response examples:

- Two teachers to a room affect this especially when the one closest to the thermostat is going through menopause. ;-)

\textsuperscript{23}

Constructing Our Niches: The Application of Evolutionary Theory to the Architecture, Engineering, and Construction (AEC) Industry

\textsuperscript{45,46}
• I would like to be able to control my office without affecting others. IE: the control is in nurse’s office and sometimes their temp. Needs to be warmer or vice versa.

• Our room is often hot AND cold. I share a space with another teacher though and sometimes I think she may be turning the thermostat up and down throughout the day.

• I do not have any outside windows in my classroom. I rely on the teacher next door to control thermostat in my room. Sometimes, just a fan would be nice to move the air around.

• One person has a thermostat in their office and they keep their door shut all the time.

• Inability to control the temperature in our individual offices. It’s sometimes stifling hot in the summer and very cold in the winter, and we can’t adjust. Also if the person in the office next door is not in, there is no way to adjust the temperature.

And here are a few examples from interviews conducted with teachers:

• One faculty with the controlling thermostat in their office apparently keeps his/her door shut all the time, according to one of the other faculty on the same zone (stated a bit annoyingly).

• One faculty with the controlling thermostat stated that no one had ever asked him to make an adjustment, but he wasn’t sure if that’s because there weren’t any issues or if other faculty were uncomfortable asking him.

• One faculty had jokingly warned the adjacent faculty member with the controlling thermostat that he was going to bring in a freeze-bag to put on the thermostat.

In some cases, teachers and staff end up resenting administration and maintenance for allowing the system to have been designed in this manner, or for not making changes to rectify the issue. They sometimes end up resenting their colleagues residing in rooms with their own thermostats, as those without individual control commonly expressed envy of those who did – it created a have/have-not dynamic. These
temperature control conflicts that sometimes involve visible inequities and forms of social undermining behavior negatively impact the ability to collaborate, the degree of cohesiveness and trust, and the working relationships in general among colleagues.\textsuperscript{52,53}

In these situations, the rules and expectations for obtaining thermal comfort end up varying by role and/or location. As a result, different sub-groups are created, separated by a thermal comfort boundary. In the end, we have a school of teachers and staff whose ability to effectively collaborate in the pursuit of a common educational goal is compromised compared to a school with effective means of providing individual temperature control.

Unfortunately, such examples of misalignment between a specific physical environment’s capabilities and the ultimate requirements of design feature 1 (strong group identity) commonly extend beyond thermal comfort inequities (though the degree of impact varies). The photo below was taken from within the media center of a New Mexico high school. The center was designed with large expanses of exterior/interior glazing flooding daylight inwards and providing beautiful outward views for the teachers and students (as well as facilitating the requirements of design feature 4 - low-cost monitoring, so that lapses of cooperation can be easily detected). Here you can see the internal glazing at an upper level, allowing views to the lower ground level, as well as beyond through the exterior glazing (not pictured).

While this solution allows substantial daylight penetration and view access, the space’s configuration, as the librarian pointed out to me, also allows those at the ground level to see up the skirts of individuals standing next to the glass on the upper level. As a result, the structure of the media center’s physical environment exacerbates potential occurrences of sexual harassment (staff to staff, student to student or between these groups) and other conflicts surrounding gender and bullying. It creates additional opportunities for harassment, discrimination, embarrassment, disrespectful behavior and bullying to occur. All of which create and/or exacerbate existing divisions within the larger school, working against design feature 1. What’s more, this misalignment could have easily been rectified had some type of applique or film been applied to the lower portion of the glazing.
Moving to an example from the corporate sector, we're currently assisting one of our corporate clients assess a free address pilot in one of their office buildings. Free address environments, also termed hot-desking, non-territorial or untethered environments, typically consist of a variety of locations and settings throughout an office that occupants may select from depending on the tasks being conducted at any given time. Such locations often consist of individual workstations, phone rooms, team or huddle rooms for individual or small group work, conference rooms of varying size, and various configurations of open spaces using a variety of furniture types. Technology is usually present throughout the office for video conferencing, conference calls, and to assist with collaboration in general.

Free address environments are often implemented in conjunction with remote working, telecommuting, job sharing, and compressed work week policies to help a) minimize total constructed or leased square footage and square footage per employee, b) maximize space utilization, c) minimize move/reorganization costs, and d) improve collaboration and communication. Though research indicates free address environments have mixed success rates.

Our client’s pilot floor plates generally consist of a) areas of unassigned workstations (first come, first served) located side by side where occupants can dock their laptops, b) more open areas furnished with a mixture of tables/chairs, less formal furniture, and mobile whiteboards and c) various conference rooms and smaller rooms for personal phone calls, heads down work and collaboration. Most of these are non-reservable. Lockers are also available for occupants to store their personal belongings during the day. While employees aren’t assigned to a specific workstation, individuals (and their departments) are assigned a specific area on a given floor, though one may choose to work in other areas and even other floors if a spot is available. We’re still in the middle of our assessment, but some observations can be made regarding the free address environment’s alignment with Ostrom’s design features.

There are protocols and best practices for working on these floors that occupants are expected to follow to help ensure a collaborative, comfortable and productive environment that benefit the occupants, their teams, and ultimately the organization. A few of these include:

- Leave the shared spaces (including workstations) as they were found, or as occupants would generally like them to be found upon their arrival each day. Everything brought with an occupant to a workstation or other space must be taken with the occupant or stored in a locker at the end of the day.

- Eat food in the café area as opposed to in the work areas (to minimize distracting odors as well as limit workspace messiness).

- For reservable spaces, be mindful of others who may also need to use them (don’t hog them).

- Adapt to meet their own personal needs. Examples include wearing earbuds or moving to other locations.

- Respectfully communicate their (unmet) needs to those around them.

Each of these free access floors have a high degree of openness; it’s easy to see, hear, smell, etc., what your neighbors are doing. The physical environment’s proximate manifestation obviously helps facilitate design feature 4 (low-cost monitoring, so that lapses of cooperation can be easily detected) – it’s easy to detect violations of most of the protocols and best practices.
Once violations are detected, enforcement of the protocols and best practices appears to primarily be by a) peer pressure, b) a concierge assigned to oversee various floors, and c) mid-level managers. Sanctions, as addressed in design feature 5 *(graduated sanctions to correct misbehaviors, which begin with friendly reminders and escalate only as needed)*, look to consist of verbal reminders from neighbors and the concierge and mid-level managers, with potentially increasing weight given to those reminders as you work up the chain. Non-verbal communication, including body language, sticking in earbuds (with exaggerated movements), sighs, etc., are also part of the communication received from neighbors. Conflict resolution relative to the protocols and best practices among occupants (design feature 6 - *conflict resolution that is fast and perceived as fair by group members*) is to be handled by the concierge first, and then mid-level managers if needed.

Initial assessments of survey results and in-context interviews and observations suggest that the peer pressure, sanctions and means of conflict resolution (design features 5 and 6) aren’t consistently effective in enforcing the free address protocols and best practices, as well as resolving associated conflicts. Potential contributing factors include:

* Increased potential for dissatisfaction and conflict. Free address environments can greatly limit the amount of control occupants have over their comfort, the nature of their workspace, and how they do their work. If a) the general indoor environmental quality (temperature, lighting, acoustics, etc.), b) the number and locations of supplemental space types (heads down work rooms, collaboration spaces, conference rooms, etc.), and c) associated protocols, best practices, etc. (including sanctions and means of conflict resolutions) aren’t effective in meeting employee and team needs, occupants will more likely violate the protocols and best practices in pursuit of their needs.

* Cross-cultural differences associated with the use of contract employees who are primarily from a non-western country. Many of these individuals have norms that differ with regards to personal space, privacy, territoriality, food, and food odor preferences, and peer pressure. This appears to be creating or exacerbating misunderstandings and conflicts between the contract employees and permanent employees around the protocols and best practices.

* Uncertainty among some occupants regarding who to speak to (or how to get in touch with the appropriate person) to resolve conflicts associated with the protocols and best practices, when peer pressure doesn’t seem to work.

This is a very preliminary assessment, but it nevertheless demonstrates the importance of aligning the physical and social/cultural environment’s proximate manifestations with the requirements of the relevant ultimate design features (Ostrom’s design features in this case). But some within the industry will point out that the design/construction process has an inherent give and take to it. Compromises will always have to be made as the design process seeks to optimize a balance (within budgetary and schedule constraints) between the vast number of pros and cons for a given client, building and occupant group. Some degree of misalignment is inevitable. Many of those same individuals would also point out that these misalignments often develop over time as occupants, space use requirements, societal expectations, etc., change. The building/occupant organism doesn’t remain
fixed once the contractor leaves the job site, and it should be viewed as an evolving entity requiring periodic adjustments, modifications and renovations.

I would agree with both points. However, my point is that by not deliberately determining what the relevant ultimate design features (and their appropriate proximate manifestations) are for a given social/cultural and physical environment, we increase the likelihood that misalignments similar to the ones discussed above will occur. And this increases the likelihood that the success of the organization in question will be negatively impacted. We can minimize the occurrences of misalignment (and the degree of their severity) by proactively taking the nature of the relevant ultimate and proximate design features into account.

Up to this point, I’ve focused on Ostrom’s eight design features, but there are other ultimate design features that should be considered as well. The next essay will broaden the discussion of ultimate design features for the building/construction industry.
In the last essay, I presented specific examples of how misalignment of an environment’s proximate manifestations with the requirements of the relevant ultimate design features for a given organization and group of building occupants results in varying degrees of failure. By not proactively taking the relevant ultimate and proximate design features into account, we increase the risk that misalignments will occur, as well as the degree of their severity.

Now I’ll broaden the discussion of ultimate design features for the building/construction industry. Conveniently we don’t have to start from scratch, as there is a wealth of existing research, best practices and expertise to draw from. Whether we’re talking about the design of utility energy conservation programs, hospital facilities or mixed-use development projects, we can use the vast reservoir of knowledge that’s out there, interpreted within an evolutionary framework, to formulate the relevant ultimate design features.

For this essay, I’ve focused on ultimate design features that are likely relevant for most facility types. Recall that design features are ultimate because of their impacts on human physiologies and psychologies, as well as aspects of our social/cultural worlds. Single individual design features often have varying impacts on all three of these areas, and they have varying relevance at multiple scales, from the individual to nested groups of ever-increasing size. This makes their categorization somewhat difficult and fluid, depending on the facility, occupant demographics, and mission of the organization in question. For now, I’ve used the following six categories: Connection to Nature, Individual Comfort / Wellbeing, Control, Enablement, Cooperation, and Competition.

By not proactively taking the relevant ultimate and proximate design features into account, we increase the risk that misalignments will occur, as well as the degree of their severity.
One source to draw from for determining ultimate design features is biophilia, the supposition that humans have an “instinctive bond” to other living systems – that we have an innate biological connection with nature – originally proposed by Edward O. Wilson.\textsuperscript{57} Evidence from research at the intersection of biology, health, psychology, architecture and urban planning suggests that biophilic design, by facilitating this connection to nature, improves the health, performance and general happiness of building occupants.

Terrapin Bright Green, a sustainable building consultant, has developed 14 patterns of biophilic design, quoted below from their guide.\textsuperscript{58} I would suggest that these patterns represent a solid first pass at formulating ultimate design features focused on the physiological and psychological connections all humans have with nature.

Nature in Space: addresses the direct, physical and ephemeral presence of nature in a space or place.

- **Visual connection with nature.** A view to elements of nature, living systems, and natural processes.

- **Non-visual connection with nature.** Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.

- **Non-rhythmic sensory stimuli.** Stochastic and ephemeral connections with nature that may be analyzed statistically but may not be predicted precisely.

- **Thermal & airflow variability.** Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.

- **Presence of water.** A condition that enhances the experience of a place through seeing, hearing, or touching water.

- **Dynamic & diffuse light.** Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature.

- **Connection with natural systems.** Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.
Natural Analogues: addresses organic, non-living and indirect evocations of nature.

- **Biomorphic forms & patterns.** Symbolic references to contoured, patterned, textured, or numerical arrangements that persist in nature.

- **Material connection with nature.** Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place.

- **Complexity & order.** Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.

Nature of Space: addresses spatial configurations in nature.

- **Prospect.** An unimpeded view over a distance, for surveillance and planning.

- **Refuge.** A place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.

- **Mystery.** The promise of more information, achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.

- **Risk/peril.** An identifiable threat coupled with a reliable safeguard.

It’s not difficult to see how these 14 patterns are rooted in our evolutionary past, the majority spent as hunter/gathers who had a much deeper and more intimate connection to the natural world than what we have today. For example, the millennia our species spent viewing the landscape around us on a daily basis led to a visual system (and the associated cues it provides to various aspects of our physiologies and psychologies) optimized for views of the natural world, not the interiors of our modern built environments. This is likely one of the reasons underlying research results that find pleasant exterior views that include vegetation can have significant impacts on office productivity, learning in educational environments, and patient recovery rates. In the last essay, the New Mexico high school media center’s proximate configuration with large expanses of exterior/interior glazing aligns well with the following Connection to Nature ultimate design features: Visual connection with nature, Dynamic & diffuse light, Connection with natural systems, Prospect and to a lesser degree Risk/peril. It also aligns well with Ostrom’s ultimate design feature 4 – Low-cost monitoring, so that lapses of cooperation can be easily detected (Ostrom’s design features will be discussed further below under the Cooperation category). However, it’s misaligned with Ostrom’s design feature 1 – Strong group identity, in that the view up people’s skirts from the lower level exacerbates potential occurrences of sexual harassment and other conflicts surrounding gender and bullying, adding a divisive element within the larger school. The addition of an applique or film on the lower portion of the upper-level glazing would have brought the proximate environment into alignment with this ultimate design feature. This demonstrates the need to address a wide range of ultimate design features having varying impacts at the individual and group level (and to assess a facility post occupancy to uncover such unintended consequences).
Individual Comfort / Wellbeing

Maintaining our comfort and well-being is a basic need that impacts individuals physiologically and psychologically. The actual and perceived comfort of an organization’s members impacts their health and resolve, and even the quality and level of coordination among an organization’s members. As I pointed out in the second essay, just as the condition of being comfortable and the associated behaviors of seeking comfort increased the fitness levels of our hunter-gather ancestors, their nuclear family groups and larger kinship structures, so do they increase the fitness levels of modern humans and the groups that they’re a part of, such as communities, school districts, or business organizations.

Decades of multi-disciplinary research have demonstrated that comfort relative to different aspects of indoor environmental quality (IEQ), such as temperature, lighting, air quality and sound, impact occupant productivity and health. Below are several examples of these impacts from various studies.

- Discomfort represented by non-optimal temperature ranges have been shown to decrease occupant performance/productivity on either side of the optimal temperature range (68°F - 72°F) by up to 9%.
- Research has shown humans also have an affinity for a limited degree of thermal variability, or thermal alliesthesia, and that providing opportunities to experience this variability increases both productivity and the temperature range we find comfortable. These findings, in line with the concept of biophilia, supplement the optimal temperature range findings discussed above.
- Compared to little or no daylighting, classrooms with appropriate daylighting may increase the rate of student learning by a) 20% in math and b) 26% in reading.
- Office workers were found to perform 10% to 25% better on tests of mental function and memory recall when they had the best possible exterior view versus those with no exterior view.
- An analysis by Milton et al. showed that workers with half as much outdoor air were 1.5 times as likely to take sick leave. This result was based on 3700 employees in 40 different buildings, all at the same company.
• Research by Allen et al. found that cognitive performance was 101% better on average under a higher ventilation rate (40 cfm/person – approximately 550 ppm CO₂) compared to conventional building conditions (20 cfm/person – approximately 945 ppm CO₂). Generalizing this finding to other contexts, MacNaughton et al. found that a $40 per year increase in ventilation is associated with $6,000 per year increase in cognitive outputs from employees.

• When conversational noise was reduced, and speech privacy increased, a) the ability of office workers to focus on tasks improved by 48%, b) the performance of tasks relating to accuracy and memory improved by 10% and c) the physical symptoms of stress such as high blood pressure and increased heart rate were reduced by 27%

Therefore, the core design features of Thermal comfort, Visual comfort, Air quality and Sound quality impact the fitness levels of both individual occupants and the organizations they’re a part of. Specific targets within each of these design features will often vary by such things as occupant tasks, building type, and demographic factors, the details of which are beyond the scope of this essay. In a competitive economic environment, how well the proximate physical and social/cultural environments are aligned with these core design features, and meet the intended targets, impact organizational and individual occupant success.

Referring again to the thermal comfort discussion from the previous essay, one of the design targets from the schools examined was for a minimum of 80% of the occupants to rate their building’s thermal environmental conditions as acceptable (which comes from ANSI/ASHRAE Standard 55). One could argue that this percentage is too low for a target, but that’s a subject for another essay. For the most problematic schools, acceptability rates fell far below this 80% minimum for many of the reasons discussed in the previous essay. The Thermal comfort design feature wasn’t met for most of these building occupants. And as previously discussed, this inability to adequately meet the Thermal comfort design feature, along with the associated temperature control conflicts that occurred, undermined Ostrom’s design feature 1 - Strong group identity among the teachers and staff at these schools.

The reader at this point may have noticed a connection between these Individual Comfort / Wellbeing design features, commonly discussed as different aspects of indoor environmental quality (IEQ), and some of the Connection to Nature design features. For example, Thermal comfort is dependent in part on successfully implementing Thermal & airflow variability. While one could potentially subsume these Individual Comfort / Wellbeing design features under relevant Connection to Nature design features (or vice versa), these categorizations reflect different potential project focuses, different intellectual traditions or approaches within the building/construction industry, and potentially different values of building owners, organizations or communities.

For example, people within and outside the building/construction industry are generally more familiar with IEQ than biophilia. Organizations and building owners are more likely to grasp the quantitative productivity and health benefits to building occupants from achieving good quality IEQ - benefits that also positively impact their bottom lines. While the research also exists demonstrating biophilia’s quantitative
benefits to health and productivity (often the same research), many decision makers or other key stakeholders still view biophilic approaches as less tangible or evidence-based than approaches focused on improving IEQ. Under such circumstances, by framing the ultimate design features using the Individual Comfort / Wellbeing categorization as opposed to the Connection to Nature categorization, we may be more likely to incorporate proximate design solutions aligned with both IEQ and biophilic ultimate design features. Regardless of the framing category used, the primary goal is to determine the most relevant ultimate design features for a given project and occupant demographic. Depending on the project, there may be other Individual Comfort / Wellness design features to consider, such as different aspects of proxemics, like personal space (which could also fall under the next framing category used, Control).
How well individuals can maintain control over their local environment, physical comfort, personal space boundaries, privacy needs, territoriality needs, day-to-day workflows, professional development, etc., impacts them physiologically and psychologically. The actual and perceived level of control that members of an organization have impact their health and resolve, and even the quality and level of coordination among an organization's members. Below are several Control design features we've found are important for the proximate environment to be aligned with.

**Personal environmental control** refers to the degree to which occupants perceive they can alter their personal environment to meet their needs. This includes modifying their environment’s square footage, layout, furniture, technology (and other tools), and IEQ conditions. Lee and Brand found that perceived environmental control (enhanced by the availability of flexible space or a variety of space types) had a significant, positive influence on job satisfaction and group cohesiveness. This suggested to them that providing employees more individual control over their individual work environments could address "... individual, interpersonal, and group needs for flexibility; this, in turn, may contribute to group cohesiveness.” And studies have shown that increasing one's degree of personal IEQ control provides average measured workforce productivity gains of 7.1% for lighting control, 1.8% for ventilation control and 1.2% for temperature control. So, achieving an acceptable level of personal environmental control not only improves satisfaction and productivity but also increases the degree of alignment with Ostrom's design feature 1 – Strong group identity.

In the free address environment example from the last essay, the relocation from previous cubicles and individual offices represented varying degrees of loss of personal environmental control for these employees. Ideally, the free address environment’s proximate manifestation should be designed to offset that loss of Personal environmental control by providing the right type and quantity of alternate work environments to meet varying employee needs (that include the avoidance of distractions). As demonstrated by this free address environment example, this is easier said than done as there was a large percentage of employees who felt an inadequate number of alternate work environments was provided.
Privacy is another important Control core design feature to consider. Altman defined privacy as the ability to regulate or control the level of desired or appropriate interaction with others. Excessive interaction results in a sense of crowding while insufficient interaction results in a sense of isolation. The definition’s focus is on creating an environment conducive to concentration and resulting satisfaction with one’s workplace. Though the control of information access or sharing also fits within this basic definition. Research has shown that perceptions of privacy are also influenced by status and type of occupation, space density (number of people per unit of area), where one is on the introvert/extrovert spectrum, and one’s ability to adapt to new environments.

The concept of territoriality refers to a suite of behaviors that individuals and groups use to signal to others the boundaries of a territory as well as prevent others from accessing the territory if necessary. In this case, territory may refer to a physically defined location, objects, or even ideas and concepts. Brown identifies four types of territorial behavior that are appropriate to consider as Control core design features.

- **Control-orientated marking**: this involves marking an object or area with symbols that communicate the territory’s boundaries, and who has psychological ownership of the territory.

- **Identity-oriented marking**: this is also known as personalization, and refers to the decoration, labeling, modification, etc., of an object or area by the owner to reflect the owner’s identity (to themselves or to other individuals or groups).

- **Anticipatory defending**: this involves taking actions to prevent others from using your territory – your objects or areas.

- **Reactionary defending**: this involves taking actions to reclaim territory – objects or areas – that others have already started using, taken or infringed upon in some manner.

All four are interrelated with one another, as well as with Personal environmental control and Privacy to a degree. For example, Wohlers and Herter argued that in free address (non-territorial) environments, where Personal environmental control, actual workstation ownership (defined territory), and Control-orientated marking of that territory are greatly limited or non-existent, allowing a level of Identity-orientated marking will increase feelings of ownership and personal control. It can help alleviate negative psychological reactions and associated actions of Anticipatory defending and Reactionary defending that can negatively impact collaboration and general working relationships – negatively impact Ostrom’s design feature 1 – Strong group identity.

In the free address example from the last essay, Identity-orientated marking of workspaces was limited primarily to personalized cups and bottles – there’s little room at the workstations to accommodate forms of personalization that must be removed at the end of each day. Employees can use the writable surface on their lockers for personalization, but that is essentially it. Based on feedback from employees, these limited forms of Identity-orientated marking are insufficient to offset the loss of the other Control design features. As with Individual Comfort / Wellbeing, all the above Control related core design features impact the fitness levels of both individual employees and the business organizations they’re a part of. Misalignment of the core design features with the proximate physical and social/cultural environments will negatively impact business and employee success.
Enablement

According to Royal and Agnew, enablement is a key human need in the workplace. Employees require a supportive work environment to be successful, one with adequate resources to complete their daily tasks. These consist of the right types of physical spaces, tools, equipment, supplies, information, organizational policies/procedures, and supportive actions from co-workers and management (the other group members). The wrong types of any of these (or lack of) can function as barriers to employees in effectively completing their daily tasks. An effective workplace enables employees, increasing their fitness levels and the groups they’re part of, including business organizations.

Workplace effectiveness, as an enablement design feature, can impact the resolve and health of an organization’s members, as well as the quality and level of coordination among those members. In an office environment, it’s measured in part through self-reports of effectiveness and satisfaction, utilization rates, observations, cost savings/avoidance (including estimated productivity/health impacts) and self-reports of workplace attachment and engagement. Other types of environments, like healthcare settings, warehouses, factories, retail settings, etc., will have additional or alternative metrics to track the effectiveness of the workplace.

In the free address environment example from the previous essay, a large percentage of employees reported an inadequate number of enclosed spaces for small group collaboration or video conference calls. The resulting increase in frequency of these activities in the free address workstation spaces led to increased distractions, decreasing the effectiveness of the workplace. And it’s important to point out that employee perceptions of workplace effectiveness are also impacted by how well the proximate environments are aligned with other relevant design features. An employee who is consistently thermally uncomfortable with little means of controlling their thermal comfort will tend to rate their workplaces as less effective, even if they have access to the resources needed to successfully complete their daily tasks.
Intragroup cooperation increases the fitness level of business organizations by increasing the level of cooperation in pursuit of common goals. Cooperation among members of an organization impacts the quality and level of coordination among the organization’s members, and their health and resolve to a lesser degree. In my third essay, I introduced Elinor Ostrom’s eight design features (listed below) that are the hallmarks of groups able to successfully cooperate in pursuit of shared objectives. The specific wording is taken directly from Wilson et al. but see Wilson et al. for a more thorough discussion.

1. **Strong group identity**: A strong group identity, including understanding and agreeing with the group’s purpose.

2. **Benefits proportional to costs**: Benefits proportional to costs, so that the work does not fall unfairly on some individuals and unearned benefits on others.

3. **Consensus decision-making**: Consensus decision-making, since most people dislike being told what to do but will work hard to achieve their own goals.

4. **Low-cost monitoring**: Low-cost monitoring, so that lapses of cooperation can be easily detected.

5. **Graduated sanctions**: Graduated sanctions to correct misbehaviors, which begin with friendly reminders and escalate only as needed.

6. **Conflict resolution**: Conflict resolution that is fast and perceived as fair by group members.

7. **Sufficient autonomy**: Sufficient autonomy for the group to make its own decisions without interference from other groups.

8. **Scalable Relations**: Relations among groups that embody the same features as the relations among individuals within the group.

I’ll reiterate that these design features solidified as adaptive in the smaller scale human societies that dominated most of human history, but they’re still functional in our modern, larger societies, with a bit of tweaking relative to a multi-level selection framework. Throughout the third, fourth, and even in this essay, I’ve provided examples of various degrees of alignment or misalignment of the physical and social/cultural environments with these design features.
Intergroup competition can increase the fitness level of a business organization when the organization responds by increasing its Functional integration and Uniformity among the organization’s members. The organization’s fitness levels may further increase if done in a manner that maximizes both intragroup unity and intergroup differentiation. Functional integration and Uniformity certainly improve the quality and level of coordination among an organization’s members and can positively impact their resolve. More specifically, each of these core design features consist of the following.

**Functional integration**: To increase a group’s ability to successfully compete with other groups, it must be composed of functionally differentiated individuals, or individuals performing the different functions required for the group to operate, and even survive. In the case of a mechanical, electrical, and plumbing (MEP) engineering design firm, the organization obviously requires mechanical, electrical and plumbing engineers and designers to provide the core services of the firm, but also Building Information Modeling (BIM) individuals, energy modelers, marketing professionals, business development professionals, accountants, HR professionals, and other administrative support staff. If these functions aren’t accounted for in some manner within the firm (or sub-contracted out externally), or if they’re not handled effectively, this impacts the firms’ ability to successfully compete against other MEP design firms for work.

**Uniformity**: Functional integration is enhanced within a group by imposing uniformity upon the members of the group in terms of their behavior relative to the successful operations and survival of the group. Proximate means for imposing this uniformity include such things as laws, social/cultural norms and organizational policies. These proximate means for imposing uniformity are capable of constraining organizational member behaviors that may be immediately advantageous for the individuals themselves at the expense of the group or organization they’re a part of. Again, looking at the example of the MEP firm, uniformity is facilitated through such things as firm-specific design standards, onboarding procedures for new employees, standards of conduct, and internal marketing/education efforts and
celebrations aimed at promoting the firm’s mission, vision, and values. Internal means for tracking uniformity include such things as engagement surveys, client surveys, and quality control procedures.

In the free address environment example from the previous essay, Uniformity, particularly relative to following the free address protocols (both explicit and implicit), was negatively impacted by the organization’s use of contractors, many of whom were from another country. Contractors, by their very nature, do not have the same ties, loyalties, etc. to the contracting organization that the organization’s actual employees do. They don’t necessarily feel the same sense of urgency or need to comply with “peer pressure” to follow the contracting organization’s office protocols (related to Ostrom’s design features 4 and 5). This is further complicated if the contractors are from a different culture with office norms that vary from what we find in the United States. For example, what constitutes an acceptable level of body odor can vary by culture, as it did in this case between many of these contractors and their western, permanent employee counterparts. An implicit part of the office protocols was to come to the office with a western defined acceptable level of body odor. There was a lack of uniformity in body odor expectations between the contractors and permanent employees that negatively impacted working relationships and organizational performance.

Uniformity is also a component of ensuring Ostrom’s first design feature – Strong group identity. That shouldn’t come as a surprise to the reader, as the framing categories of Cooperation and Competition are closely intertwined. The most successful groups in a competitive environment are able to effectively cooperate internally. In general, these framing categories are artificial constructs used to organize the ultimate design features for a given community, facility type, occupant demographic group, and organizational mission/values. Other framing categories (and additional design features) may make more sense to use, depending on the specific project in question. For example, Wilson et al.’s ten simple truths important for education environments are likely candidates for education-focused design features.

As pointed out above and in previous essays, the successful implementations of these core design features – their proximate manifestations – will look different in different social/cultural and physical environmental contexts. And there must be the right mix of proximate manifestations of all the above core design features to ensure that individual self-interests driving within-group competition don’t override our social drive for unity and cooperation at the organizational level. The proximate manifestations must minimize the potential for selfish behaviors that negatively impact the organization, as well as make the best use of our pro-social tribal instincts. A post-apocalyptic, dystopian office environment forcing individuals and groups to compete for comfort, control and resources isn’t what we’re after.

The final essay discusses how the planning, design, construction, and operations process can better account for the relevant ultimate design features and determine their most appropriate proximate manifestations. But before that, the next essay discusses this ultimate/proximate relationship relative to the guidelines, standards, and codes used within the building/construction industry.
In the last essay, I broadened the discussion of ultimate design features for the building/construction industry, focusing on six categories of features likely relevant for most facility types and occupant demographics - Connection to Nature, Individual Comfort/Wellbeing, Control, Enablement, Cooperation, and Competition. It's important to recognize that the most appropriate proximate manifestations of these ultimate design features will look different in different social/cultural and physical environmental contexts. And there must be the right mix of proximate manifestations of all the above core design features to ensure that individual self-interests driving within-group competition don’t override our social drive for unity and cooperation at the organizational level.

In this essay, I’m discussing the relationship between ultimate design features and their proximate manifestations relative to the standards and codes used within the building/construction industry. For those unfamiliar, the Whole Building Design Guide, a program of the National Institute of Building Sciences, provides a succinct overview of codes and standards – what they are, how they’re developed and how they’re used. Both generally serve as minimum requirements for the manufacture, construction/assembly, and performance of various building attributes, often with a focus on public health, safety and general welfare. However, there are also what’s known as stretch, reach, or green codes that go beyond the minimum requirements found in base codes (energy efficiency being a common example).

Codes are developed with the intention of adoption by jurisdictions to serve as criteria for the design, construction, and operations of our built environment. Standards, however, may or may not be developed with this regulatory intent in mind, but if adopted by a jurisdiction they do become code. In general, codes and standards provide a measure of consistency and guidance for designers, builders, and code officials.

But to further increase consistency across regions and the nation as a whole, model codes have been developed by various organizations with the intent of potential adoption by Federal, state, and/or local governments, or other organizations. Model codes can also help facilitate a faster incorporation of the latest information and research and reduce the cost of code development. This consistency is a key evolutionary benefit at multiple levels within contemporary society. It provides a greater assurance for building occupants, regardless of where they live or travel to within the U.S, that they will experience a minimum level of quality and safety in the facilities they find themselves in. Referring back to the last essay, the quality of the physical environment and the safety it affords can be considered part of the Individual Comfort/Wellbeing set of ultimate design features, and ensuring that the contextual environment is aligned with these ultimate needs increases occupant relative individual fitness levels.

For example, consider the Wilder Block building, a 130-year old, four-story structure in Brattleboro, VT, that was rehabilitated during
the 1990s. Working with local fire safety officials, the design/construction team was able to develop design solutions that achieved an equivalent level of safety as required by state/local adoptions of the National Fire and Life Safety model codes, while also preserving the building’s historic character. One such solution involved the original glass transoms above the doorways to each building unit. They weren’t self-closing and so could not provide an effective barrier to smoke and fire spreading into or out of the individual units. Instead of destroying the historic nature of the building by replacing the original doorways and transoms, automatic door closers were added, and the transoms backed with plywood. The closers decreased the risk that doors would remain open during a fire, and the plywood backing increased the fire rating of the transoms to the minimum code required level, increasing the time it would take for smoke or fire to penetrate the transom.

During a subsequent 2004 five-alarm fire, this solution proved a reliable barrier, preventing the penetration of fire and smoke into the individual units. This solution, along with other code-compliant renovation solutions, allowed all the building occupants to evacuate without any loss of life. It’s a textbook example of how building codes help align proximate solutions with ultimate needs to increase individual fitness levels.

Moving to the level of the group, as I discussed in the second essay, norms (that include formal building codes and standards) "...help create common experiences and expectations among group members, binding them together. As a result, they help suppress within-group selection among group members that can disrupt the cohesiveness of groups, ensuring that between group forces dominate."26 Specifically, codes and standards help drive the standardization of materials, systems, building configurations, construction methodologies, and operational procedures, increasing the uniformity within the building/construction industry among manufacturers, designers, buildings, and building owners. Such industry-wide standardization provides a unifying force at the level of the community, state, and nation-state to help each level operate more efficiently. In this case building codes help ensure that unity and other group level ultimate needs of Cooperation and Competition, discussed in the last essay, are met, increasing their respective fitness levels.

In the case of the Wilder Bock building, the normalized expectations and potential design solutions available through a) the uniformity provided via similarities in codes and standards, b) widely available building materials and equipment, and c) a common building/construction intellectual tradition, set the stage for an affordable solution meeting the ultimate design needs in question. The functional integration provided through the different design professionals, contractors, manufacturers, code officials, and other key stakeholders contributing their own parts to the final solution, enhanced by the uniformity just mentioned, further ensures a successful outcome to a complex problem. And by successfully meeting the occupant and owner needs, public trust in the overall system of code development, design/construction, and oversight from code officials is maintained, contributing to a strong group identity and ensuring that the economic and political stability offered by a well-functioning building/construction industry continues.

Tragedies that unfortunately occur, such as the Station nightclub fire, Hyatt Regency walkway collapse, and the Oakland Ghost Ship fire (sometimes exacerbated by the political weakening of code adoption and enforcement), undermine this trust, even if the eventual outcome is a stronger set of building codes,
better design, and more effective enforcement. Such tragedies may also result in a loss of code enforcement flexibility, negatively impacting the ability to meet other ultimate needs. The successful outcome for the Wilder Block building came about because of local code officials’ flexibility in finding a solution they deemed provided an equivalent level of safety. A less flexible interpretation could have required replacing the original doors and transoms, negatively impacting the building’s historic nature. A loss of local history removes some of the common bonds that tie a community together, negatively impacting its group identity and uniformity, and ultimately its relative fitness.

This doesn't mean that the uniformity within the building/construction industry contributed to by codes and standards results in limited to no competition among designers, contractors, etc. But if there is generally sufficient work for everyone (i.e., the local environment is capable of supporting the current population), the competition for individual projects typically doesn't include extensive efforts to put the competition out of business. Codes and standards, code enforcement (i.e., low-cost monitoring), maintaining professional reputations (i.e., Graduated sanctions) and the legal ramifications (i.e., Graduated sanctions) also restrict the actions potentially taken by design firms and contractors to increase their profit margins at the expense of the final project's quality and safety. More cut-throat competition is an indication that within-group selection is rivaling or dominating between-group selection forces, contributing to instability at the community or larger social level.

As already alluded to, code consistency, or more specifically the potentially associated inflexibility, can unintentionally contribute to instability. It can lead to (or at least contribute to) misalignments of local level proximate manifestations with ultimate needs. There may not be enough flexibility built into a code or standard to begin with to allow adequate adaptation to local conditions or local code officials may adopt a generally inflexible approach. I’ve already discussed the benefit of code interpretive flexibility in the case of the Wilder Block building. And standards, while not necessarily having the regulatory requirements of codes, are sometimes applied by designers in an inflexible manner, or at least without fully understanding the context in which they were developed. This too can lead to misalignments of ultimate needs with proximate manifestations of the physical environment.

In the fourth essay, I mentioned how BranchPattern’s post-occupancy evaluations of pre-K – 16+ campus environments found thermal discomfort to be a too-common occurrence, particularly for students. One of the reasons for this is design solutions often don’t adequately account “...for how variation in demographics (age, gender, clothing, etc.) impacts thermal comfort.” ASHRAE Standard 55 and ISO 7730 Standard for “Ergonomics of the thermal environment” are both standards used to help maximize thermal comfort in the built environment. But as pointed out in a report by the Committee to Review and Assess the Health and Productivity Benefits of Green Schools, both are based on experimental studies of adults, not children (or young adults).

As I’ve pointed out elsewhere, the metabolic rate estimation methods and predefined clothing insulation values recommended for use by these standards to model thermal comfort during design don’t adequately address a) younger physiologies, b) the variation in clothing insulation values between adults and students, and c) the wide variation of clothing insulation values among students. Yet many designers and modelers use these methods and values in education environments without attempting to adjust for the varying ultimate needs of students. This results in a greater thermal discomfort among students, negatively
impacting their ability to learn (at least compared to an environment better capable of meeting their thermal needs).

One disadvantage of codes and standards is that they’re only updated every 3+ years, delaying updates that could improve the alignment of people’s ultimate needs and their proximate environments. This is compounded by the fact that for a variety of reasons ranging from inertia to implementation and construction cost implications, the versions of model codes adopted by municipalities are often one or more cycles out of date. Sustainability is often negatively impacted because the only real driver in many locations is relative to the requirements for energy performance mandated by the local building energy code. If it’s several cycles out of date, then the current best practices with regards to energy performance aren’t mandated and associated utility savings and emissions reductions aren’t obtained.

Certification systems, such as LEED, BREEAM, and the WELL Building Standard, provide municipalities and building owners the option of exceeding out of date code requirements or of even going beyond current model codes. However, unless aspects of these certification systems have been mandated and/or incentivized in some manner by municipalities, utilities, or other relevant organizations, their use is sometimes limited. They have an associated certification cost and can also add varying amounts to the costs associated with design, construction, and operations, though the percentages are often comparatively small. Providing the associated return on investments from utility savings, quantified occupant productivity and health benefits, increased rental rates, and other operational benefits can help make the decision-making process more prosocial and longer-term in nature, but not always. And certification systems suffer from the same potential update cycle limitations as codes and standards.

Stretch codes, though, if adopted, provide municipalities the ability to establish a vision and set of goals for energy efficiency (or other aspects of sustainability, health/wellness, etc.) looking forward ten to twenty years as opposed to being tied to the 3+ year cycle of updates. This also gives the market time to react to and accommodate any needed new practices and technologies. Businesses, universities, school districts, etc., can all see what will be required of their existing, or potentially renovated or new buildings, for years down the road. And because such codes are typically performance or outcomes-based (as opposed to prescriptive-based), they have greater flexibility in adopting new technologies, methodologies, or understandings of relevant ultimate needs as they develop over time. Stretch codes, when properly implemented, help facilitate longer-term assessments of costs and benefits, as well as the environmental and societal impacts beyond the individual building or project. At the level of the community, state or nation, they have even greater potential than non-stretch codes at minimizing within-group selection forces that can overly disrupt unity, cohesiveness and group identity.\textsuperscript{e.g.26}

The next essay represents the culmination of the series. It focuses on the planning, design, construction, and operations processes themselves, discussing what we can do to better account for the relevant ultimate design features of a given project and determine their most appropriate proximate manifestations.
In the last essay, I discussed the relationship between ultimate design features and their proximate manifestations relative to the standards and codes used within the building/construction industry. Ideally, codes and standards are developed, implemented, and enforced in such a manner to establish normalized expectations of safety and performance, while also building in enough flexibility to better ensure that local level proximate manifestations are aligned with ultimate needs.

This essay represents the culmination of the series, and it focuses on taking a building project from early planning all the way through its initial occupancy, and beyond. Specifically, I’m looking at how we create an overall process, rooted in an evolutionary framework, that forms a cohesive group of stakeholders bound in the common pursuit of determining the relevant ultimate design features and their proximate manifestations.

In the third essay, I discussed the process of integrated design, laying out a few reasons why it ends up being successful or not relative to two of Elinor Ostrom’s ultimate design features necessary for effective cooperation among group members. Looking at Ostrom’s fourth ultimate design feature — low-cost monitoring, so that lapses of cooperation can be easily detected – I discussed how the owner’s project requirements (OPR) document “... holds everyone accountable to the project’s vision and goals throughout the design/construction process.” It does this by providing “… transparency... of 1) the nature of the project’s vision and goals, 2) design or construction changes that impact the vision and goals, 3) who instigated the changes, and 4) why the changes were made and what impacts they’re estimated to have.”

When successful, the integrated design process has engaged all the relevant key stakeholders of a project. This helps satisfy Ostrom’s first design feature - a strong group identity, including understanding and agreeing with the group’s purpose. Bringing the key stakeholders together early on in the process, from the architect and contractor, to building owner and facility manager, and to the occupants themselves, is critical for establishing buy-in of the project vision, scope, and goals, as well as binding the group together in pursuit of these common goals. The building/construction industry, however, doesn’t consistently engage all the key stakeholders to determine everyone’s values and needs, even in applications of integrated design. This often contributes to varying degrees of misalignment between ultimate design features and their proximate manifestations, many examples of which have been provided throughout this series of essays. If the industry deliberately operated within an evolutionary framework, then additional significance would
be associated with engaging every relevant key stakeholder group. Designers would more consistently distinguish between ultimate needs and proximate manifestations and consider how evolutionary forces operating at multiple levels both shape and are constrained by the nature of this ultimate/proximate relationship.

Cases of thermal discomfort misalignment, several examples of which were discussed in previous essays, are often contributed to by inadequately involving certain key stakeholder groups, such as students or women, in the planning, design, or post-occupancy assessments. Maybe students aren’t included on planning committees or given the opportunity to provide feedback. Maybe the core design/construction team and owner/organizational representatives include few or no women, limiting the inclusion of their perspective as design decisions are being made. As a result, some relevant ultimate needs or required proximate manifestations to meet those needs are missed. And the particular history of HVAC in North America, discussed in the second essay, has increased the likelihood of thermal discomfort misalignments.

While this is an oversimplification (see the second essay for more details), the industry’s eventual standardization on forced air HVAC systems as the dominant system type, driven in part through the particular unfolding of HVAC’s development in North America, increased the uniformity within manufacturers, designers, builders and business owners. Even though forced air systems aren’t the most optimal for achieving occupant thermal comfort, the uniformity obtained via standardization provided a selective advantage in and of itself to these organizations, the building/construction industry, and society at large. In the absence of a design decision-making process that quantified estimates of occupant productivity and health (and therefore those impacts at both the higher group level and the individual CEO or shareholder), uniformity at the higher group level dominated thermal comfort needs at the lower occupant level. Historically, this has contributed to an increased likelihood of thermal discomfort.

As with integrated design, shortcomings are also found in Human-Centered Design (HCD) approaches. Human-Centered Design is both a framework for viewing the design process, as well as a set of methodologies for carrying out design. As a framework, it places human end users, and their interactions with the environment, systems or product in question, at the center of the design. The methodologies employed are intended to determine the contextual user (and organizational) needs and abilities, so that the capabilities of the physical environment, systems, technology, or product in question are designed to be in alignment with the determined user needs and abilities. Many of the methodologies employed are similar to what you would find in an integrated design process and include charrettes, ethnography, surveys, modeling, design iterations, and reviewing secondary research results on cognitive impacts, social interactions, organizational operations, and other building/occupant interaction findings. It’s a process grounded in the relevant information about the people who will be using the buildings, systems or products being designed.

It’s that heavy focus on the contextual needs of the end user or occupant consistently gathered in part through ethnographic methods, that set it apart from other design frameworks and methods used in the building/construction industry. It can be particularly effective at identifying needs of the occupant and their organizations, as well as the optimal proximate manifestations, but it doesn’t view their
relationships from an evolutionary perspective. Until HCD operates specifically within an evolutionary framework systematically distinguishing between ultimate needs and proximate manifestations, it will never reach its full potential either.

---

**Bringing the key stakeholders together early on in the process, from the architect and contractor, to building owner and facility manager, and to the occupants themselves, is critical for establishing buy-in of the project vision, scope, and goals, as well as binding the group together in pursuit of these common goals.**

---

What’s needed is a process operating within an evolutionary framework that combines key aspects of integrated design and HCD. To form a cohesive group of stakeholders bound in the common pursuit of a project’s goals, it’s particularly important that the process address the **Collaboration** (Ostrom’s design features) and **Competition** ultimate design features discussed in the fifth essay. In general, the following four general tasks are what I see should be incorporated.

1) **Identify Key Stakeholders:**
   From the earliest phases of a project, identify all the relevant key stakeholder groups. These include the financiers, designers, contractors, commissioning agents, other specialty consultants, facility operators, the organizational/occupant groups, authorities having jurisdiction (AHJs), and potentially community groups. Including all relevant groups helps ensure that the various needs are accounted for, that the most optimal proximate solutions are generated, that everyone’s voice is heard, and that buy-in for the final solution is obtained. It’s the first step to meeting Ostrom’s first, second, third and seventh ultimate design features, as well as the design features of **Functional Integration** and **Uniformity**. Here are some of the ways that they are relevant.

   - **Strong group identity** (Ostrom Feature 1): This includes understanding and agreeing with the group’s purpose. For example, identifying all the relevant key stakeholders early makes it more likely the overall group will solidify around an agreed-to vision and set of goals than if some stakeholders are brought on board later in the process.

   - **Benefits proportional to costs** (Ostrom Feature 2): It’s important that the work doesn’t fall unfairly on some individuals and unearned benefits on others. For example, relevant to the design/construction team and building owner, it’s important that from the very beginning, expectations regarding different team member scopes of work, schedules, and associated fees are clearly articulated and agreed to by everyone. If the contract holder expects more effort for a given fee than understood by those being contracted, working relationships, and ultimately the success of the project, could be negatively impacted.

   - **Consensus decision-making** (Ostrom Feature 3): Most people dislike being told...
what to do but will work hard to achieve their own goals. For example, stakeholders brought on board later in the process may not be vested in the vision and goals that were already established and may actively work to undermine them. Stakeholders that were never brought on board, or feel they’ve had no input in the decisions made, likely won’t have any buy-in of the final solution.

- **Sufficient autonomy** (Ostrom Feature 7): Sufficient autonomy is needed for the group to make its own decisions without interference from other groups. For example, in some circumstances, the involvement of certain key stakeholders early on could ensure that this collective team of stakeholders has the autonomy needed to make needed decisions. In the Wilder Block building example from the last essay, the involvement of the AHJ (local fire safety officials) in the design process allowed the development of a solution deemed code compliant, as opposed to being presented the design after the fact, and potentially interfering with design decisions already made.

- **Functional Integration**: A group needs to be composed of functionally differentiated individuals, or individuals performing the different functions required for the group to successfully and competitively operate. For example, the more effort expended on identifying and including the relevant key stakeholders early, the more likely that the relevant functions necessary for successful completion of the project, such as all the necessary design specialties, will be included.

- **Uniformity**: Successful operations, functional integration, and cooperation of group members are greatly enhanced by imposing uniformity upon these members relative to their behavior. For example, early identification of the relevant key stakeholders and their involvement in establishing schedules, budgets, scopes of work, communication protocols, etc., helps ensure a degree of uniformity among the key stakeholders involved relative to the completion of the project.

2) Establish Vision and Goals

As a group, establish an agreed-to vision and set of goals for the project in question. These are subsequently used to guide the establishment of project requirements, performance targets, design concepts, building operational policies, etc., as well as provide something at a high level to hold everyone accountable to throughout the process. Methods used to facilitate this often include some type of charrette, workshop, or visioning session, sometimes supplemented with surveys and ethnography. These are performed to uncover relevant values and desired outcomes, how they vary among the key stakeholders, look for commonalities and reconcile any major differences to finalize on a vision and set of goals. Ostrom’s first and third ultimate design features, as well as the design feature of **Uniformity**, are particularly relevant.

- **Strong group identity** (Ostrom Feature 1): This includes understanding and agreeing with the group’s purpose. For example, establishing a vision and set of goals as a group, that everyone is generally in agreement with, increases the strength of the group’s overall identity relative to the completion of the project.

- **Consensus decision-making** (Ostrom Feature 3): Most people dislike being told what to do but will work hard to achieve their own goals. For example, establishing the vision and goals through a form of consensus decision-making will help ensure that they’re adhered to throughout the process and that key
stakeholders will buy-in to the final solution.

- **Uniformity**: Successful operations, functional integration, and cooperation of group members are greatly enhanced by imposing uniformity upon these members relative to their behavior. For example, an agreed-to vision and set of goals help unify the overall project group throughout the process as the group seeks to complete the project within the constraints of the vision and goals.

Ideally the vision and set of goals should be prosocial as opposed to selfish with respect to the overall organization, community, and society. From an evolutionary perspective this means that we want to develop a vision and set of goals for the project that benefit the group, and that also don’t benefit specific individuals in the short term at the expense of the larger group over the long-term (i.e., generate profits to sustainably accomplish a shared vision vs. having a vision focused solely on generating profits primarily for the leaders and shareholders).

Research, including my own, suggests that “...the more people involved in a decision-making process (even indirectly), the less likely short-term, localized costs/benefits will dominate the process at the expense of longer term, much broader formulations of costs/benefits.” For the design/construction process, encouraging decision makers to be more inclusive and transparent, soliciting the opinions of employees, partners, patrons, community members, etc., will increase the likelihood that visions and goals will be more prosocial in nature. Early identification and inclusion of all the relevant key stakeholders help ensure this.

3) Determine Ultimate Features/Needs & Proximate Solutions:

Obtain an understanding of the relevant key stakeholder group ultimate features, or needs, with respect to the project’s vision and goals, and then determine the best proximate solutions of the ultimate design features identified. As I pointed out in the third essay, this requires obtaining an understanding of the following three items, graphically depicted here.

1. How the physiological and psychological constraints that result from our evolutionary history, in turn, have shaped our individual and group needs, behaviors and decision making in various modern group settings.

2. How our evolutionary history spent primarily as hunter/gatherers has shaped the social/cultural tools we have available for living and interacting in group settings.

3. How the appropriate proximate manifestations of these ultimate design principles are determined by a) who the specific individuals and groups are (and how they’re nested together), b) what their physiological and psychological needs consist of, and c) what their social/cultural and physical environments currently and/or need to consist of.

Six categories of ultimate features, or needs, are discussed in the fifth essay, and these tend to be relevant for most projects. Others may also be relevant depending on the demographics of the key stakeholders involved, the facility type (or organization’s mission), and scope of work. Some ethnographic work to better understand those being designed for combined with secondary research (similar to what was used in the fifth essay) may be needed to determine the most appropriate ultimate features, or needs, for a given project.

Once these are determined, then they, along with the vision and set of goals, can be used to establish the performance targets (relative to occupant comfort and health, indoor...
environmental quality (IEQ) conditions, energy consumption, utility costs, work order rates, etc.) and other owner project requirements. These provide the general constraints used to work within while formulating the proximate design solution options to consider.

To determine the most appropriate proximate design solutions, there are many methods and tools to pull from traditional, integrated and HCD approaches for use in conjunction with one another. These include (but aren’t limited to):

- More in-depth engagement of building occupants, building operators and potentially community members through surveys and ethnographic methods. This effort may be accomplished at the same time such engagement is performed for establishing the vision and goals, as well as the relevant ultimate design needs/features. Or it may be an additional effort.

- Secondary research examining previous design solution applications and their resulting performance.

- A series of design iterations at various scales throughout the design process - internal to an individual firm’s project team, involving the whole design/construction team, and the entire key stakeholder group. Within this iterative design process, occupant group representatives, organizational leadership, building operators, and potentially community members depending on the project, should participate in developing design concepts as well as providing feedback on the design as it progresses.

- Virtual reality and/or physical mockups can be used as part of the iterative design process to help key stakeholders more fully experience different options for proximate design solutions and provide informative feedback. These are both powerful methods for providing contextual feedback and uncovering unintended cases of misalignment for a physical environmental context that doesn’t exist yet.

- Modeling to predict performance (energy, comfort, etc.) of design concept options using various software packages. This modeling should involve some form of life cycle cost analysis that takes a comprehensive look at costs and benefits, including such things as quantitative estimates of impacts on occupant productivity/performance and health, operational costs relative to potential work orders and systems maintenance, and even larger community, environmental and societal impacts, such as greenhouse gas emissions.

Ostrom’s first, second, third, sixth, and eighth ultimate design features, as well as the design feature of Functional Integration, are particularly relevant.

- **Strong group identity** (Ostrom Feature 1): This includes understanding and agreeing with the group’s purpose. For example, engaging the building occupants and building operators as part of the iterative design process, elevating them to the status of a designer in a manner of speaking, increases the strength of the group’s identity around a common set of project goals.

- **Benefits proportional to costs** (Ostrom Feature 2): It’s important that the work doesn’t fall unfairly on some individuals and unearned benefits on others. For example, making the building occupants, building operators, organizational leadership and other relevant key stakeholders active participants in the design process helps
ensure a proximate outcome that meets the most optimal combination of the relevant stakeholder’s ultimate needs. We don't want an outcome where some stakeholders appear to benefit at the expense of others.

- **Consensus decision-making** (Ostrom Feature 3): Most people dislike being told what to do but will work hard to achieve their own goals. For example, making non-design/construction team members an active part of the design, part of the decision-making process, better ensures needs are met, alignment is achieved, and buy-in is obtained.

- **Conflict resolution** (Ostrom Feature 6): This should be fast and perceived as fair by group members. For example, as the design process proceeds, various conflicts will arise relative to needs, wants, and costs. There will be disagreements among stakeholder groups and individuals relative to the selection of certain proximate design concepts and the exclusion of others. It’s rare that anyone gets everything they want, but people should feel their concerns and desires were heard and thoughtfully considered. This is required for the process to be perceived as fair.

- **Scalable Relations** (Ostrom Feature 8): The relations among groups should embody the same features as the relations among individuals within the group. For example, it’s important that implementation of processes to address these ultimate design features at the level of the whole key stakeholder group is also reflected at the level of the design/construction team. Unsuccessfully addressing these ultimate design features among the design/construction team members will negatively impact the ability of the larger key stakeholder group to collaborate in common pursuit of the project goals.

---

**Functional Integration:** A group needs to be composed of functionally differentiated individuals, or individuals performing the different functions required for the group to successfully and competitively operate. For example, if the necessary specialty consultants haven’t all been engaged for a specific project, such as an acoustician, anthropologist, envelope commissioning agent, etc., then all the tasks needed to formulate a proximate design aligned with goals, performance targets and other requirements won’t be effectively performed or performed at all.

---

**4) Maintain Accountability**

Methods and tools are required for helping ensure that the prosocial vision, goals, performance targets, and other owner project requirements are adhered to throughout the process, from initial planning until years after initial occupancy. This requires keeping the group cohesive and focused on the same goals, as well as verifying that the facility has been constructed to, and performs to, the original design intent. As with the previous step, there are many methods and tools to pull from traditional, integrated and HCD approaches for use in conjunction with one another to achieve this. A few of these that aren’t always consistently included are:

- In general, it’s important to keep key stakeholders engaged throughout the process. This needs to occur throughout at least the first year of occupancy (through the warranty phase). While it’s true that most groups will not have the same level of involvement through this timeframe (i.e., subcontractors may be more heavily involved during construction than during design), the transparency provided by keeping everyone generally engaged helps the project adhere to the original goals.
One of the benefits of project delivery methods like Construction Manager at Risk (CMAR) is that they ensure contractors are involved earlier in the process.

- Above and in the third essay I discussed how the owner’s project requirements (OPR) document holds everyone involved accountable to the project’s vision, goals, performance targets and other requirements throughout the design/construction process, in part because of its ability to maintain transparency.

- The modeling process discussed in the previous step, combined with the virtual reality and physical mockups, provide indications of how potential design solutions may or may not meet performance targets and other owner requirements. It’s important that the results of these actions are transparent to the key stakeholder group as a whole.

- Commissioning provides a comprehensive process to ensure that systems are designed with the operator in mind and installed/constructed and initially performing per design intent. In addition, commissioning agents often work with building owners and operators to implement processes and tools that help ensure the building is operated per the design intent for the long term, including after eventual turnover of building operating personnel. However, while the occupant’s perspective is typically considered in the commissioning process, there tends to be more of a focus on the building operator. Adding a more deliberate consideration of the occupant during the commissioning process would increase the effectiveness of commissioning.

- After one year of occupancy, a comprehensive post-occupancy evaluation (POE) is needed to ensure that the facility is still performing per the original goals, performant targets and other requirements. If cases of misalignment are found, adjustments should be made to bring them into alignment and lessons learned should be carried forward to other projects, shared with the industry, and used to evolve the process itself. A comprehensive POE process includes engagement of building occupants through surveys and ethnography, measurements of IEQ conditions, estimated impacts on productivity and health, assessments of building energy and water consumption, utility and other operational costs, and...
potentially other building audit or recommissioning efforts.

- Similar assessments, recommissioning, or even continuous or ongoing commissioning, should occur throughout the life of the facility, to keep ultimate needs in alignment with the proximate manifestations. But it’s important to recognize that as building occupants or even organizations change over time, the relevant ultimate needs could also change.

Ostrom’s first, second, fourth, fifth, and sixth ultimate design features, as well as the design feature of Uniformity, are particularly relevant.

- **Strong group identity** (Ostrom Feature 1): This includes understanding and agreeing with the group’s purpose. For example, a group with a strong identity focused on the pursuit of the project’s goals is easier to hold accountable for meeting those goals.

- **Benefits proportional to costs** (Ostrom Feature 2): It’s important that the work doesn’t fall unfairly on some individuals and unearned benefits on others. For example, the OPR document, if formed through a consensus decision-making process involving the relevant stakeholders, establishes requirements for the subsequent design that limits some stakeholders benefiting at the expense of others.

- **Low-cost monitoring** (Ostrom Feature 4): This is needed to easily detect lapses of cooperation. For example, the OPR, the modeling, mockups, and virtual reality, the commissioning testing activities, and POEs are among the many opportunities available to help facilitate monitoring deliberate or accidental lapses of cooperation.

- **Graduated sanctions** (Ostrom Feature 5): This is needed to correct misbehaviors, which begin as friendly reminders and escalate only as needed. For example, these friendly reminders are often manifested in group collaborations of some sort (meetings or otherwise), where someone simply points out that some decision, design choice, etc., doesn’t meet some aspect of the OPR, or is anticipated to not meet a performance target. Worse case scenarios could escalate up to termination from a project, or litigation.

- **Conflict resolution** (Ostrom Feature 6): This should be fast and perceived as fair by group members. This is similar to the example discussed in the third step.

- **Uniformity**: Successful operations, functional integration and cooperation of group members are greatly enhanced by imposing uniformity upon these members relative to their behavior. Effectively implementing accountability measures will improve or at least help maintain the uniformity among the key stakeholders with respect to achieving the project’s goals.

This high-level outline can be implemented on projects in a variety of ways. The scale of its implementation will certainly vary by project type and scope of work, but the ideas laid out in each of these four general tasks need to be systematically addressed on each project in some manner. In many ways, it’s about creating an evolutionary based, human-centered mindset of engaging the necessary stakeholders to align proximate design solutions with their relevant ultimate needs.

BranchPattern has developed its own HCD framework that follows the outline above. We call it the **D.I.V.E. Project Framework™**. It spans...
from pre-design through post-construction services (and beyond) and is broken down into the four phases of Discovery, Iteration, Validation, and Evolution. As of early August 2018, we’ve a) piloted elements of D.I.V.E. on several projects, b) rolled out a company-wide internal training program, and c) begun a more deliberate push for day-to-day implementation of the framework.

We believe that this will ultimately minimize the occurrences of misalignment (and the degree of their severity) by proactively taking the nature of the relevant ultimate and proximate design features into account. And that it will contribute to the design, construction and operations of more sustainable and regenerative built environments that better meet the productivity and health needs of building occupants and organizations, as well as minimize, and even reverse, the built environment's contributions to climate change. We don’t want to be the puddle in Douglas Adams' fable, doomed by an overly limited perspective of our environment that blinds us to the nested relationships of a complex world.
References


Brussels, Belgium.


This View of Life is the online magazine of the non-profit think tank The Evolution Institute, which applies evolutionary science to pressing social issues, deploying a multi-disciplinary team of experts in biology, the social sciences, and Big Data. Projects of study include the Norway Initiative on global quality of life, the Urban Initiative on sustainable community and educational development, and Sheshat, a large, multidisciplinary database of past societies, used to test theories about political and economic development.

Consider joining the TVOL1000, a group that supports the magazine, helps to shape its content, and otherwise works to establish “this view of life” as a worldview for accomplishing positive change.