Lisa Heschong

Thermal Delight in Architecture

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Preface

This work began with the hypothesis that the thermal function of a building could be used as an effective element of design. Thermal qualities—warm, cool, humid, airy, radiant, cozy—are an important part of our experience of a space; they not only influence what we choose to do there but also how we feel about the space. An analogy might be drawn with the use of light quality as a design element, truly a venerable old architectural tradition. The light quality—direct, indirect, natural, artificial, diffuse, dappled, focused—can be subtly manipulated in the design of a space to achieve the desired effect. Thermal qualities might also be included in the architect's initial conception and could influence all phases of design. Instead, thermal conditions are commonly standardized with the use of modern mechanical systems that can be specified, installed, and left to function independently of the overall design concept. Indeed, environmental control systems tend to be treated rather like the Cinderella of architecture; given only the plainest clothes to wear, they are relegated to a back room to do the drudgery that maintains the elegant life-style of the other sisters: light, form, structure, and so forth.

I became intrigued with the design potential of thermal qualities when I was working on the design of a solar building. Rather than simply housing an autonomous mechanical system, the building itself acted as the thermal system. The living room was both for living in and for collecting heat. The south windows allowed a view and also let in the warmth of the winter sun. Thermal shutters, closed at night, made the house more introverted while also saving heat. I began to wonder how the thermal qualities of this building affected peoples' experience of it. I realized that there were very few references on which to draw. The one obvious analogy was the fireplace. The solar-heating functions of the building were essentially a replacement of the original thermal functions of the fireplace. With its circle of warmth, the fireplace had once been the center of family life. Its dancing light, smoky smells, and warm crackling created an ambience that made a house more a home. And the traditions around the hearth stretched back through the ages, connecting each house to deep cultural roots. How might the solar house incorporate some of the richness of the hearth? What were the qualities of the hearth that made it so wonderful and so beloved?

I decided to look not only at hearths but at places with strong thermal qualities from a broad spectrum of cultures and historical periods, with the assumption that there was a universality of human experience that might be distilled from them. I have looked at the examples not with the eye of a historian (How did it come to be?) or of an engineer (How does it work?) but rather with the eye of a designer

(How is it perceived? What role does it play in peoples' lives? What is wonderful about it? How is it part of a greater whole?). Unfortunately, information on peoples' actual use and experience of places tends to be sparse. It is perhaps a sad commentary on the state of architectural literature that so little attention is paid to how people ultimately use spaces and what they feel about them. The most illuminating descriptions are often written by anthropologists, literary travelers, or poets.

Other than the hearth, perhaps the richest example of a thermal place with a profound role in its culture is the Islamic garden, the cool oasis that is the traditional center of the Islamic house. Together they might be regarded as two archetypes: the hearth, a refuge of dry warmth from a cold world, and the oasis, a preserve of coolness and moisture in a desert wilderness.

It is hoped that this collection of disparate examples may serve as a set of references for the designer. It draws no firm conclusions and sets no guidelines; rather, it offers some background information and a bit of musing, which are the first stages of any design work.

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Daily Life in Ancient Rome
by Jerome Carcopino,
published by Yale University Press, 1940.

The Islamic Garden
edited by Elizabeth MacDougal and Richard Ettinghausen,
published by Dumbarton Oaks, 1976.

Suye Mura, A Japanese Village
by John F. Embree,
published and copyrighted by The University of Chicago Press,
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American Building: The Environmental Forces That Shape It, 2d ed.,
by James Marston Fitch,
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by Sir James George Frazer,
edited by Theodor H. Gaster.
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Man, Climate, and Architecture
by Baruch Givoni,
published by American Elsevier Publishing Co., 1969.

Energy and Form: An Ecological Approach to Urban Growth
by Ralph L. Knowles,
published by The MIT Press, 1974.

The City in History: Its Origins, Its Transformations, and Its Prospects
by Lewis Mumford,
published by Harcourt, Brace, and World, Inc., 1961.

Design with Climate
by Victor Olgyay,
published by Princeton University Press, 1963.

The Temple and the House
by Lord Raglan,
published by Routledge and Kegan Paul, 1964.

The Prodigious Builders
by Bernard Rudolfsky,
published by Harcourt Brace Jovanovich, 1977.

One Hundred More Poems from the Chinese: Love and the Turning Year
copyright © 1970 by Kenneth Rexroth.
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Design for a Limited Planet
by Norma Skurka and Jon Naar,
published by Ballantine Books, a Divison of Random House, Inc., 1976.

Topophilia: A Study of Environmental Perception, Attitudes, and Values
by Yi-Fu Tuan, © 1974, pp. 9, 10.
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Englewood Cliffs, N. J.

Sauna: The Finnish Bath
by H. J. Viherjuuri,
published by the Stephen Greene Press,
copyright 1972.

Village in the Vaucluse, 2d edition,
by Lawrence Wylie,
published by Harvard University Press, 1964.

The Japanese House and Garden
by Tetsuro Yoshida,
published by Frederick A. Praeger, Publishers, 1955.

Contents

Necessity

Life exists within a small range of temperatures. It comes to a standstill as water freezes and even the hardiest of bacteria are destroyed in boiling water. Each species of plant or animal has definite limits within which it can survive and an even narrower range of temperatures where it can successfully compete with other animals. Ecologists have discovered that as little as a 2°F change in the average temperature of a lake will shift the dominant fish population from bass to catfish as one species becomes more efficient than the other. Thus, not only extremes but even subtle variations in temperature can be critical to an animal's survival.

The oceans, where life evolved, provide a particularly stable thermal environment where organisms can live without much thermal stress. Fish and other cold-blooded sea creatures can function perfectly well at the temperature of their watery environment because the temperature of the ocean, and thus of their bodies, varies so little, and then only very gradually. The land, however, experiences great swings of temperature. The surface of the earth is constantly heating up and cooling down with each daily cycle and each yearly cycle. The ground, in turn, heats the air around it, driving the forces of weather that can so dramatically change thermal conditions over the course of a few hours. In order to move out of the oceans and onto the land, organisms had to develop thermal strategies that would allow them to survive both climatic extremes and wide daily fluctuations.

The most direct way to cope with an adverse climate is simply to not be there when it gets too hot or too cold. Many of the simpler forms of life, such as bacteria, fungi, and yeast, stop metabolizing—essentially stop living—when the temperature becomes inhospitable. Yeast can be stored in a refrigerator almost indefinitely. Put it back into 90°F water and it comes most prolifically alive. Many plants and insects solve the problem similarly. They live only during the most favorable season; then before dying off, they leave seeds or eggs behind that will sprout or hatch only when the next good season arrives.

If, however, an individual is to survive through a yearly cycle of seasons, it must employ some thermal strategy more sophisticated than simply not being there. One way not to be there, without dying, is to be deciduous, a strategy employed by plants not only in snowy climates but in desert climates as well. By dropping all of their leaves, they reduce their exposure to temperature extremes. Metabolic activity continues, but at a greatly reduced level, withdrawing to a protected core or to roots sheltered underground. Cold-blooded animals and a few of the smallest mammals have a similar strategy to deal with extreme cold: they hibernate. The metabolic rate of a cold-blooded animal, or any organism for that matter, is closely tied to the temperature of its body. As its temperature rises, it becomes more active, and as its temperature falls, it becomes sluggish and lethargic. When the environmental temperature becomes too cold, cold-blooded animals simply give up the effort to function and go into hibernation. Like deciduous plants, they retreat to a place sheltered from temperature extremes, a nest underground or within the insulating wood of a tree. As the body temperature drops, the metabolic rate is greatly reduced, enabling the animal to conserve energy for survival through the dormant period.

Animals have a great thermal advantage over plants because they can move about. Rather than endure the thermal conditions of one place, they can choose the most favorable location. Good travelers, such as birds and large herd mammals, can migrate between entire climatic zones so that they never have to endure the worst of any particular region. Migration is a way not to be there without a seasonal pause in activity. On a smaller scale, animals can also move about to take advantage of the variations in climate that occur within a given landscape. The slope of a hill that faces the sun or is sheltered from a cold wind will be warmer than the opposite slope. Indeed, this variation in microclimate can be so significant that entirely different communities of plants will grow on the opposite sides of a hill, each community thriving in the climate to which it is best adapted. An animal, on the other hand, can select among the various microclimates according to its needs. Snakes, sluggish from the night's cold, will crawl out of their holes to bask in the morning sun. With the sun's heat they can raise their body temperature considerably and begin to function effectively even though the morning air may still be quite cold.

Indeed, cold-blooded animals have surprising abilities to maintain a steady body temperature in spite of swings in the external temperature. Terrestrial cold-blooded animals, unlike fish, are not completely at the mercy of their thermal environment. In addition to moving to the best thermal location, they can also wilfully vary their muscular activity to generate more heat within their bodies. On a cold day butterflies will vibrate their wings for several minutes to warm their muscles enough so that they can fly. Lizards can maintain a body temperature to within 1°F of their optimum by combining these two strategies: to warm up, they do "push-ups" on a sunny rock; to cool down, they retreat to a shady crevice and lie still.

It is the genius of the warm-blooded animals, the birds and the mammals, that they evolved with a system for regulating their internal body temperature that takes full advantage of the heat naturally generated by their metabolism. Mammals have refined the muscular heat-generating technique of the cold-blooded animals so that a change in muscle tone can produce subtle gradations in the amount of body heat produced. Vibrations of the muscles have become an automatic shivering response as an emergency heat-generating measure. Over longer periods of time many mammals can actually raise their basal metabolic rate to acclimate to cold.

Even more significant than the ability to change the rate of heat production is the capability of warm-blooded animals to regulate the rate of heat flow away from their bodies. Although all animals generate heat from their metabolism, only the warm-blooded animals can control how fast their heat is lost. They have a variety of mechanisms that allow them either to release their excess heat into the environment to stay cool or to so thoroughly insulate themselves that their body heat is retained even in the coldest of places. Panting or sweating creates evaporative cooling from the mouth or skin. Birds do not have the ability to sweat, so on a hot day one is likely to find them splashing in a puddle or bird bath, cooled by the water's evaporation.

One of the most important ways to regulate the flow of heat is through the circulation of the blood. Mammals and birds can control how much blood is flowing to the surface of their skin, even to entire extremities. By flushing the skin with blood, the heat of the inner body is pumped to the surface where it can readily escape. Conversely, by restricting the flow of blood to the surface, the blood's heat is retained in the animal's inner core. Many waterfowl can cut off most all blood flow to their legs in order to reduce the heat lost to the cold water.

Mammals and birds have also developed a marvelous variety of ways to insulate their bodies. Fat, which occurs in other animals only as lumps that store food energy, is deployed in many mammals as a special insulating layer under the skin. Its thickness varies in response to seasonal demands for protection against extra cold. Polar bears and husky dogs have such an effective layer of fat that they can comfortably sleep on ice. Human beings, too, have this subcutaneous fat that can thicken in response to cold. Fur or feathers provide another type of insulation, one that is exquisitely variable. Over the course of a year it can change in quality, quantity, even color. Smooth and sleek and a bit oily in the summer, fur or feathers protect the owner's skin from the sun's hot rays. In winter an extra downy undercoat is grown that can be fluffed up at a moment's notice to provide an even thicker, more effective insulation. Getting goosebumps when we are suddenly chilled is a remnant of response from the time when our ancestors still had fur to fluff. A coat of fur or feathers essentially traps a bubble of air that has its own climatic conditions; the animal's skin is exposed not to the prevailing climate but to the warmer air contained within the downy fur.

When in the course of evolution human beings lost the thick mammalian fur coat, they also lost its capabilities for thermal control. Our naked skin functions adequately in the hot, humid tropics but needs some assistance in other climates. The traditional clothing developed by various cultures often has extremely sophisticated thermal functions. The billowing white robes of the Arab reflect away the sun's radiation while helping to fan air past the body and increase evaporative cooling. At the other extreme, the fur parka of the Eskimo keeps in both body heat and water vapor from perspiration so that the Eskimo essentially lives within a semitropical environment.

Of all the creatures, human beings have the greatest variety of thermal strategies available to them. Our mammalian heritage gives us metabolic adjustments that allow us to maintain comfort over quite a spread of thermal conditions. In addition to this ability for metabolic fine tuning, we have other strategies available to us. Like the lizard and butterfly, we can consciously vary our muscular activity to increase or decrease heat production. Rubbing your hands together or stomping up and down brings immediate results when you need to warm up. Such thermal responses have even developed into regional patterns. In hot climates the cool morning is usually the time of most activity, whereas during the hot afternoon everything slows down. Siesta time ensures that people's own heat production will be kept to a minimum during the hottest part of the day.

A human parallel to long animal migrations can be seen in the common tradition of a special summer place. The British in India simply packed up during the hottest months and moved business, the colonial government, and all social life up to hill stations, towns in the Himalayan foothills where the air was cooler. Similarly, New Englanders have a strong tradition of summer cottages. Many families maintain a cottage somewhere in the country or along the seacoast where on weekend visits or for a whole summer's vacation they find relief from the hot city and delight in the pleasures of the countryside. Wealthy families often extend this migration system to include a midwinter trip to Miami or the Bahamas to escape the bitter January cold.

Migration, however, is an expensive solution, whether in terms of the energy an animal must use to travel long distances or the time and money that people must spend. And before cars, trains, and airplanes, human migration was extremely slow. Preindustrial people could not travel very quickly, especially when moving a household. Ralph Knowles gives a good description of the seasonal migrations of the Piute Indians of the Owens Valley in California. Note that the total distance traveled is only thirty miles round trip:

> From permanent settlements, generally located in the most favorable microclimate, including a good water supply, the Piutes made seasonal migrations as village groups. Each summer, as the days began to lengthen

and the temperature began to climb, the group moved west into the higher meadows of the Sierras. Here they enjoyed the coolness of an increased elevation. As the fall approached and passed into early winter, they migrated ten to fifteen miles to the east, where they gathered pine nuts at the base of the White Mountains. Here they were at a lower elevation and had a west and somewhat south exposure adding to their comfort as the winter days approached. The seasonal cycle was finally completed when they returned to their permanent campsite at the base of the Sierras to live out the winter in the relative comfort of huts that could be heated fairly well.[1]

Nest building is, in a way, a more advanced version of choosing the best microclimate. An animal seeking out a rock crevice or hole in the earth as a place to rest and be cool is indeed seeking out a favorable microclimate. Digging the hole a little deeper and adding a bit of shed fur for insulation are simple improvements. All animals start their nests by finding the best location and only a few of the most talented nest builders—such as some birds, beavers, and Homo sapiens—can completely transform an environment to meet their nesting needs. The Anasazi Indians of the southwestern United States were remarkably clever in choosing the sites for their cliff dwellings. They invariably chose locations shaded in the summer by an overhanging ledge of the cliff, but exposed to full sun all winter long. With their backs to the cliff, the dwellings were protected from the winter