A Physiology of Building:
Reptilian, Canine, and Monstrous

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> The unconscious disguise of physiological needs under the cloaks of the objective, ideal, purely spiritual goes to frightening lengths — and often I have asked myself whether, taking a large view, philosophy has not been merely an interpretation of the body and a *misunderstanding of the body*. . . .
>
> I am still waiting for a philosophical *physiciati* in the exceptional sense of that work — one who has to pursue the problem of the total health of a people, time, race or of humanity — to muster the courage to push my suspicion to its limits and to risk the proposition: what was at stake in all philosophizing hitherto was not at all "truth" but something else — let us say, health, future, growth, power, life.
>
> – Friedrich Nietzsche[1]

> The failure of an artificial tool to protect man, leads to impaired physical resistance. His health is unbalanced. If by the power of his tools the re-generation of his degenerated physique fails, man's health declines in a progression from fatigue to death. *The fundamental denominator, therefore, to account for the validity of an technological environment is man's health.*
>
> – Frederick Kiesler[2]

Modern environmentalism originated with the mid-nineteenth century discovery or recognition of ecological connectivity and that paradigm of understanding has been at odds with mechanistic explanations ever since. By the 1930s Lewis Mumford predicted that ecological thought would eventually "displace the mechanical arts" and, in large measure, that displacement has been realized in the sciences, in computer networks, and in the popular imagination.[3] As he observed in the conclusion to Technics and Civilization, "form, pattern, configuration, organism, historical filiation, and ecological relationship are concepts that work up and down the ladder of the sciences: the esthetic structure and social relations are as real as the primary physical qualities and the sciences were once content to isolate." The difficulty in a first-year graduate course on environmental systems, whose very name suggests the ecological and cybernetic theories on which it is based, is that the mathematical tools and concepts with which students are comfortable are themselves largely linear and mechanisitic. The equations of heat exchange, ventilation, illumination levels, and so on, were simplified both for pedagogical reasons and also for the use of the profession in the years before the general availability of the computer. Dynamic models and computer simulations add a great deal to the explanations of complex system behavior, but it seems that no matter how simple the interface, these tools still operate as "black-boxes" for the beginning student.

The challenge for a first year course is to both teach the basic skills and methods concealed within sophisticated models and to introduce students to the most complex and counter-intuitive devices and configurations, to develop an accurate intuition about environment systems. This paper offers a discussion of a course developed to meet those goals and an argument for some of its methods. The class meets for two hours once a week throughout the intensive first year, so there is little time for repetition or a steady build up to complex issues. We have therefore adopted a hybrid approach, shifting back-and-forth between lectures on broad technical and theoretical issues and working sessions covering the basic methods of calculation and simulation. The work performed by students includes regular problem sets and exams that combine simple calculations, direct measurement of environmental conditions, and analytical determinations. Both semesters feature a larger research project, the first on distinguished precedents, and the second on an undistinguished local building that can be examined directly.

JUDGMENT AND TYPOLOGY

Beginning with the premises of inter-connectivity, and accepting Nietzsche and Kiesler's contention that health and an interpretation of the body are the fundamental premises of technological and philosophical analysis, the course has been subtitled Building Physiology. A series of corporeal analogies have been adopted to make the architectural concepts of connectivity vivid to students in advance of the formal skills required to model them. In architectural terms, we attempt to look at the complex and subtle tradeoffs that occur in environmentally sophisticated buildings without lapsing into a preference for the simpler, pre-technological aspects of construction. It is equally important to resist the hope that the next and newest device or mechanism — better burners, more efficient lamps, etc.—will relieve architects of the need for judicious planning and design. There is an overly simple opposition that occurs in architectural discourse between the traditional elements of architecture — walls, roofs, windows, and doors— and the numerous technological devices that have been inserted into or on top of them." That distinction exists at many levels and is codified in the professions that deal with them— engineers versus architects — as well as in the degree of design or composition with which they are treated. One role of core technology courses is to introduce young architects to those cultural and disciplinary distinctions at the same time that those boundaries are transgressed.

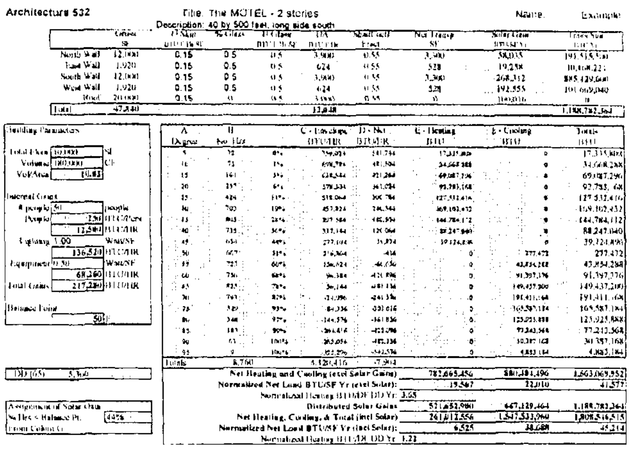
We look equally at the technological nature and effect of the formal elements of architecture, at what is often called the natural or passive condition of buildings, and at the architectural character and presence of mechanical or electrical devices. While no easy answers are offered — the differences are deeply embedded in professional practices as well as cultural characterizations — the two classes of elements are productively interdependent and have evolved together over time. The contemporary building has hybridized its collection of prosthetic accessories, and architectural judgments about them are never formulated without reference to the body. The concepts and mechanisms of physics which are taught in the first portion of the course are wholly bound up with the presence of the never-quite-abstract observer (represented by the "just noticeable difference") and through the cultural concepts of comfort. climate, and nature. Questions about pollution or ecology originate with basic bodily fears, while those fears are themselves in turn negotiated through construction and inhabitation.[5] These concepts are all deeply historical, and it is only in the imaginative examination of everyday habits that we can understand the invention of living, ecological buildings from their inanimate pieces. So, as we teach students about the result of the empirical sciences, and introduce them to the concepts of ecological connectivity in building design, we continually return to the understanding, and misunderstanding, of the body that they imply.

ORGANIZATION

The fall semester of the course concentrates on small buildings, while bigger, more complex buildings are investigated in the spring. That division is both pedagogical, advancing from simple to complex, and also essentially typological, as it is divided according to the important distinction between climate-dominated and internal-load-dominated buildings.' That distinction can be explained in a single session, but it requires the entire year to reform the student's intuitive reliance on the lessons of the climate-dominated building. Most people grow up in buildings or even apartments that respond directly and relatively immediately to the outside climate, providing heat when it is cold and cooling when it is hot. The different environmental typologies are explained by analogy of physique and with the results of dynamic computer simulations (Energy 10). In the early years of the course, a single-zone dynamic temperature simulation was used directly by the students, but it remained a "black-box" for most of them and we have settled on the use of a bin-method spreadsheet program to provide understandable distribution charts of building energy use. Explanations of building typology are presented through lecture in the fall and then in the spring the students use the spreadsheet directly in short exercises and on their final research project.

Using analogies of physique, the climate-dominated intuitive strategies are called *reptilian* because they describe the activities of a cold-blooded creature, seeking warmth and insulation when cold and avoiding them when warm. Intuitive heating strategies also derive by analogy with clothing, insulation equals warmth, though the first example of a non-reptilian logic is the overheated athlete who must remove clothing while exercising, even in winter. The strategies of the fully-sealed and air-conditioned modern building are called *canine,* because they are always overheated and can only employ strategies of ventilation; they cannot perspire or alter their insulation and so must pant, using their chillers, air-handlers and cooling towers. Very few contemporary buildings rely on purely canine strategies (only perhaps the glorious post-war towers like the Seagrams building) and the logic of the their modification is one of the most important result of the course. The counter-intuitive limitations to the use of insulation, the interaction of electric lighting, daylighting, and cooling, and the reverse effect of plan configuration are all part of the canine logic that results from the dominance of internal loads. The most interesting typological category are called *monstrous,* because they successfully combine reptilian adaptation and canine mechanization. Atrium buildings, load-shifting buildings, breathing-envelopes, and Le Corbusier's *murs nuetralisant* all exemplify the monstrous results of cross-breeding between architectural and mechanical types. Resource and energy are implicitly used to order these strategies, but the architectural dimension of environmental judgment can develop only by considering the achievements and contradictions of whole buildings. It is rarely possible to optimize every aspect of a project and the resulting compromises form the environmental ethic of building. The simple analogies of physique help capture the character of those distinctions, while the dynamic simulations and the bin-method calculations provide the necessary element of rigor.

Through the first semester these subtleties are elicited with historical examples that sharpen the awareness of typological distinctions and the tradeoffs they embody. Some of the questions they pose cannot be answered decisively and those may contribute most to the refinement of the student's judgment. Two such examples from the fall portion of the course



Architecture 532 File: The MOTEL - 2 stories Name: Example
Description: 40 by 500 feet, long side south

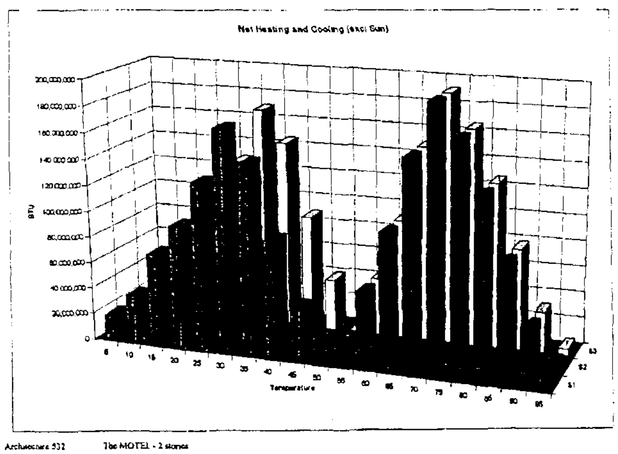


Fig. 1. Bin Method Chart of "The Motel:" Climate Dominated and Reptilian.

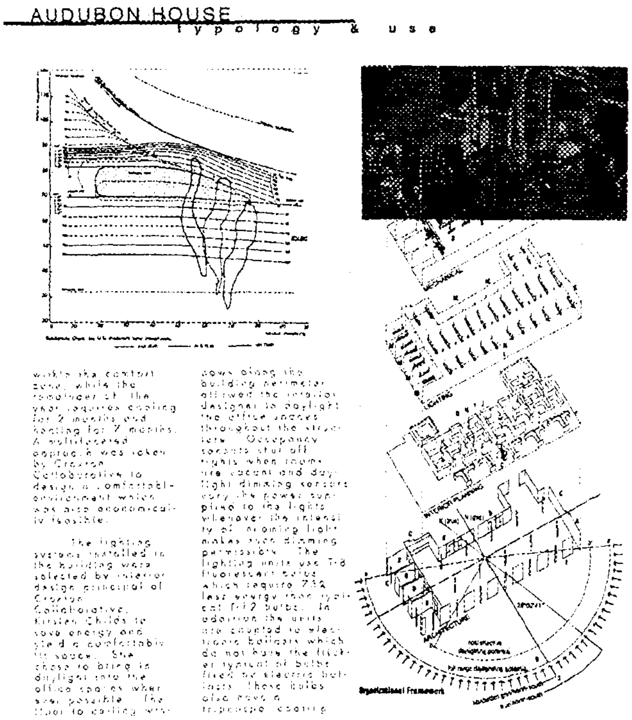


Fig. 2. Group Presentation, Fall, 1996 (J. Fung, C. McCoughlin, T. Tai, A. Tarver, T. Wang): Croxton Collaborative, Audubon House, NY, 1989.

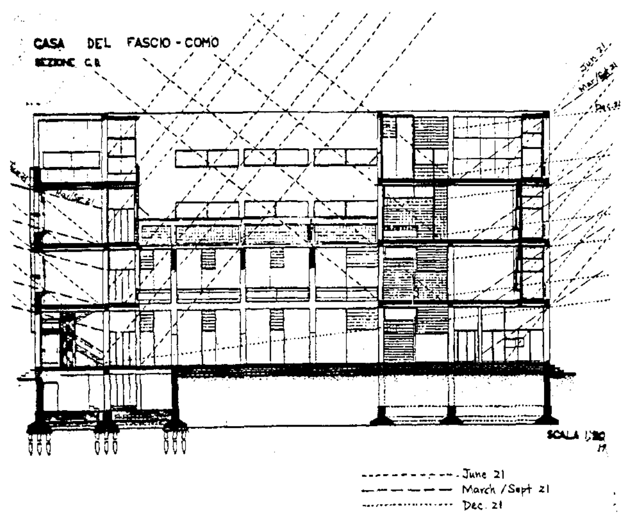


Fig. 3. Group Presentation, Fall, 1996 (C. Ames, J. Chu, S. Masui, M. McCormick, A. Yung): Giuseppe Terragni, Casa del Fascio, Como. 1936.

are the "pre-technological window" and the "building-become-machine." In the first instance a window from the early 18th century is examined both for its environmental connections — light, air, etc.—and for the habits of life that it engenders.[7] The interaction between needs and devices is not static, they progress together, and the window helps explain the impossibility of a "perfect" technology. The second example focuses on a local research laboratory that from the back appears to be nothing but a device for moving air through exhaust hoods in order to protect the occupants from the products of their research. When does a building become a machine, or is everything a machine if looked at from the right point of view? Those questions culminate in a group research project investigating and presenting the environmental features of a distinguished contemporary building. Recent examples have included Philip Johnson's Glass House, Richard Neutra's VDL Research House, Frank Lloyd Wright's Fallingwater, The Croxton Collaborative's Audubon House, and Giuseppe Terragni's Casa del Fascio. Students are always excited to discover, for example, the thoroughness of Terragni's sun angle analysis and the effort to achieve sustainability in the Audubon House.

The spring semester begins with an examination of an architecturally compelling and analytically challenging example of *monstrosity*—the ventilated double wall—in an effort to condense the issues of the course. What had apparently begun as the discovery by Le Corbusier of the insulating value of double-glazing in his early Swiss houses subsequently developed into a kind of obsession with the idea of circulating conditioned air between the panes of glass. The glass wall, which is transparent to sight, actively conditions or neutralizes the eternal climate hence his term, *mur neutralisant*. A simple heat loss calculation shows the inefficiency of this arrangement, half the energy is lost (or gained) to the outside, and the Saint Gobain glass company even built a test cell, empirically demonstrating that fact, though noting that it did provide a more comfortable radiant environment.[8] But the idea of the double, ventilating glass wall persisted and was transformed through the decades. It offers to the students a demonstration of the close interaction between technical innovation. contemporary ideologies, and architectural representation.

Le Corbusier's idea was readily copied through the 1930's, in high-rise proposals by Frederick Kiesler, and in the Loomis house by William Lescaze, which had a double glass wall employing two separate air-conditioners, one for the interior and the other for the space within the envelope.[9] The goal in that case was to maintain a sub-tropical climate with a view of the hills of New York State. The idea reappears in the 1970's transformed by the concerns of the energy crisis; the air in the wall is now moved by natural forces, providing heat in the winter and ventilation in the summer. Lee Porter Butler's "Double-Envelope" houses were much discussed at the time.[10] Related schemes were developed for commercial buildings: Alan Chimacoff's building at the Enerplex center in Princeton and particularly the headquarters of the Occidental Chemical Company of 1981, in which "two fully glazed window walls (the outer one insulating glass) 4 feet apart create an enormous nine-story passive solar collector with automatic venting dampers at the top and bottom."[11] In recent years, the renewed interest in ventilation, spurred on by the attention to Sick-Building Syndrome, have added yet another dimension to the fascination with ventilated double glass walls. An array of projects have been proposed or built testing variations of the concept, particularly in Germany where the climate is more favorable for year-round natural ventilation in commercial buildings.

The combination of a wholly transparent configuration with an invisible and "natural" technical device appeals to both the engineering criteria of elegance and the architectural fascination with physical devices. The explicit attainment of better health through ventilation adds a critical dimension to the idea of a perfect, working transparency, and it reveals the extent to which even the most refined technical accomplishments interact with cultural and physiological beliefs. The poles of that unity are neatly represented by two images from Richard Roger's Commerzbank in Frankfurt: the diagram of the double, ventilating glass window and the "dream image" of perfect transparency." The one expressing the attainment of total visual surveillance through transparency, and the other showing the invisible, environmentally friendly, and sophisticated forces at work maintaining that visual regime. It is a powerful and compelling configuration whose brief history helps instruct students in the degree to which environmental systems operate at the heart of contemporary construction.

The final project of the semester involves the complete environmental analysis of a room in a building on campus. Physical features such as temperature, humidity, and light level are measured, while performance features such as lossiness, daylight factor, and reverberation time are calculated from information gleaned from plans and direct observation. Students determine the room's environmental typology with the spreadsheet program and must use that designation to help explain the mechanical/electrical equipment and the general configuration of the room. Ultimate environmental connections — air, water, power, etc.—are traced to their sources and documented as an aspect of the room. The report encourages a haptic appreciation of the concepts developed in the first semester and also reveals the degree to which even the simplest room exists in a vast network of social and environmental connections.

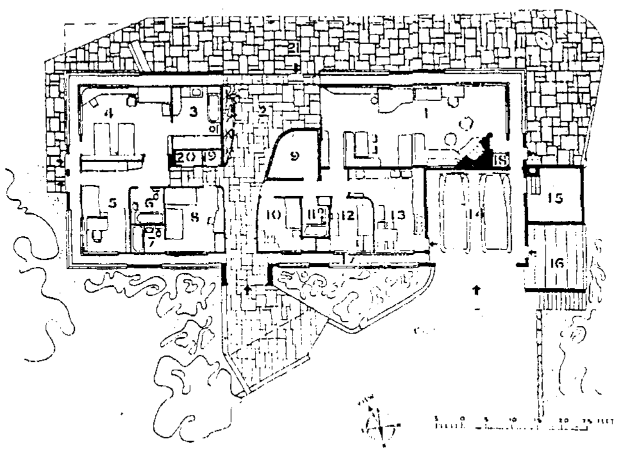


Fig. 4. Ventilating glass wall, William Lescze. Loomis House, Tuxedo Park, NY, 1938.

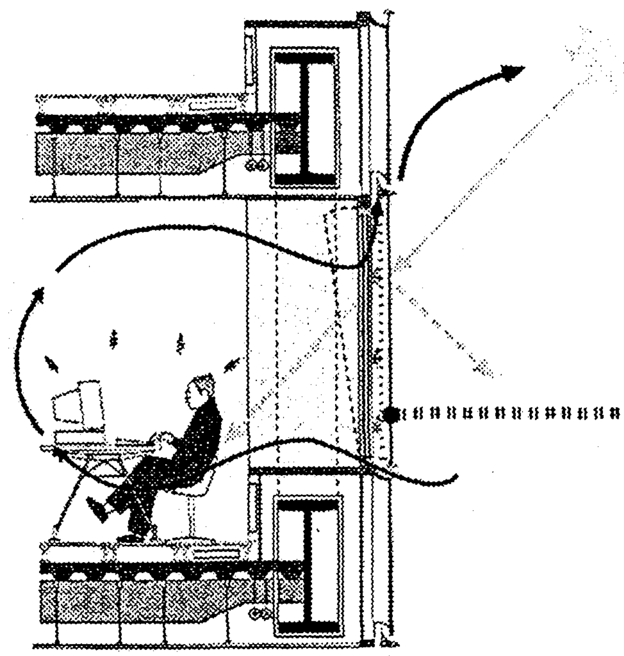


Fig. 5. Detail of ventilating glass wall, R. Rogers, Commerzbank, Frankfurt, 1997.

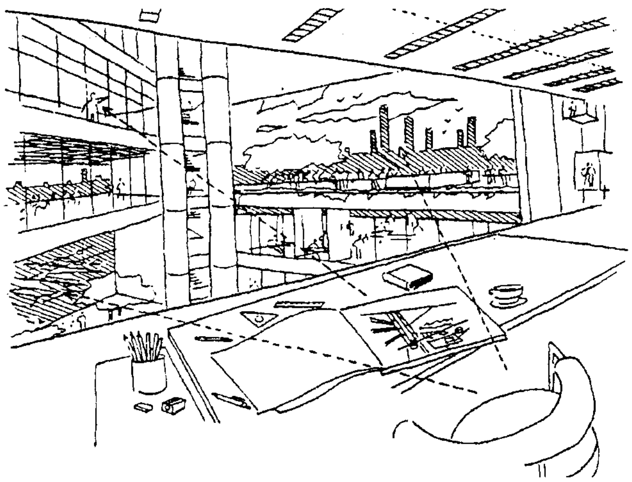


Fig. 6. "Dream image" of ventilating glass wall, R. Rogers, Commerzbank, Frankfurt, 1997.

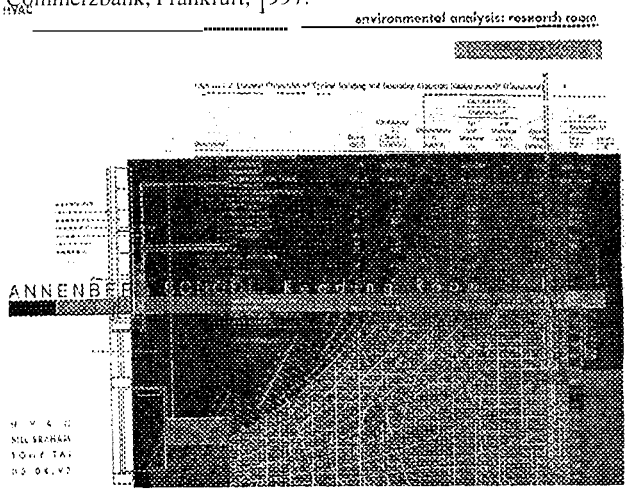


Fig. 7. Cover of final research report: John Fung, Spring, 1997

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