THIRD EDITION

Understanding Architecture

Its Elements, History, and Meaning

LELAND M. ROTH

AND

AMANDA C. ROTH CLARK

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Louis I. Kahn, The Phillips Exeter Library, Phillips Exeter Academy, New Hampshire, 1965–1971. A good example of what Louis Kahn meant when he said "architecture is what nature cannot make." Photo: Carol M. Highsmith Archive, Library of Congress, Prints and Photographs Division.

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Preface

This book is about learning to understand our human-made environment. It is about architecture as a physical vessel, a container of human activity. But since architecture is a social activity, building is also a social statement and the creation of a cultural legacy. Moreover, every building, whether a commanding public structure or a private shelter—whether a cathedral or a bicycle shed—is constructed in accordance with the laws of physics in ways that crystallize the cultural values of its builders. This book is an introduction to the artistic urge that impels humans to build, as well as to the structural properties that enable buildings to stand up. It is also an introduction to the silent cultural language that every building expresses. This book, then, might be thought of as a primer for visual environmental literacy.

I should clarify that this is not a *history* of architecture in the normal sense of the word. There is historical information in the second part of the book, but the first part focuses on how the aesthetics of architecture influence our perception.

The first edition of *Understanding Architecture* was published in 1993, and numerous additions were made in 2005 for the second edition. In this third edition, the material is brought up to date, including developments since the opening of the new millennium. This restructuring, however, necessitated rethinking how to tell the story of twentieth-century architecture. Hence, there are now revised chapters on the development of Modernism: how it was defined in Europe in the first third of the twentieth century, then how it was exported around the globe in the second third of the century, and, finally, how reactions to Modernism proliferated and have diverged in the last third of the century and have continued into the opening of the twenty-first century. Up to the mid-twentieth century, architects tended to work primarily in their native countries, aside from those who were obliged by political or religious persecution to flee their homelands and seek refuge elsewhere, such as Walter Gropius, Mies van der Rohe, and Erich Mendelsohn.

Discussion of this late-twentieth-century international dimension to contemporary architectural practice has brought into focus the realization that global cultural influences have been in effect for more than twenty-five hundred years—a period in which early trade and exploration brought various parts of the world together. As it seems appropriate to examine these global interactions and the architecture outside of the Western world, we have interspersed the main text with special essays that sketch how other cultures first began to interact with Western culture. And just as the original chapters with their Western focus never aimed to examine the full breadth of architectural history, even less do the new essays try to cover the breadth of architecture outside the West; rather, the endeavor has been to explore the encounters and interchanges, conflicts and accommodations between the disparate global communities. Since limited space precludes providing an illustration of every building mentioned, readers are encouraged to avail themselves of the various encyclopedias and search engines available online to locate images for review.

Since the Protestant Reformation, the West has preferred to stress the written cultural record, whether historical or literary, and to give little serious attention to the meaning of visual imagery. In the United States, in most community schools (other than some private academies) there are no courses in the history of art, much less on architectural history. It is usually not until college that students first encounter art history and perhaps the history of architecture. Hence, very few young people are taught how to "read" or otherwise interpret the physical environment in which they will live and work. In a very few secondary schools, students are offered classes in the visual arts, music, and dance, even though only a fraction of them will put such knowledge to use explicitly when they enter the work world. In fact, because of worsening public budget constraints, even these few classes are increasingly being cut. As a result, most people are taught next to nothing about the architecture they will encounter throughout life; they learn very little about the history of their built environment or how to interpret the meaning of the environment they have inherited. What they know is—literally—what they learn "in the street." This environmental illiteracy has long been accepted as the normal state of affairs.

This book seeks to bridge the gap. It is aimed at the inquisitive student or general reader interested in learning about the built environment and the layered historical meaning embodied mute within it. In short, it is intended not as a comprehensive historical survey tracing the entire evolution of built forms but rather as a basic introduction to how the environment we build works on us physically and psychologically, and what historical and symbolic messages it carries.

The basic structure of this book grew out of my outline for the architecture section of a telecourse, "Humanities Through the Arts," produced in the 1970s by the Coast Community College in Fountain Valley, California, and by the City Colleges of Chicago. The idea was that architecture should be examined not only as a cultural phenomenon but also as an artistic and technological achievement. The content of the book was subsequently developed in introductory courses on architecture that I taught at The Ohio State University, Northwestern University, and the University of Oregon.

The assumption behind the book's form and organization is that the reader knows little in either a technical or historical sense about the built environment. Hence, Part I of the book deals with the basic properties of architecture. It is here that basic design and technical concepts are outlined and a working vocabulary is introduced. Then, in Part II, the historical evolution of architecture is explored through an examination of basic cultural themes, with selected buildings as case studies. Such a division enables the reader of, say, Chapter 12, on Roman architecture, to focus on the symbolic image presented by the vast dome of the Pantheon, since the essential structural properties of domes have already been dealt with in Chapter 3.

Part I, then, begins with a definition of what architecture is and continues with chapters that explore space, function, structural principles, and elements of design. Individual chapters deal with how architecture affects and is affected by climatic elements, what the role of the architect has been over time, and what has been considered good or economical architecture. The discussion in Part I is illustrated by building examples drawn from all parts of the world, past and present.

Part II is a historical survey of architectural development in the West, from prehistoric times to the present. In all these chapters, the focus is on architecture as a cultural artifact, as a systematized statement of values. This leads to the concluding argument that what we build today, whether privately or on a grand public scale, is an embodiment of our values. Interspersed are new essays on interactions between Western architecture and other cultures: the architecture of India, Islam, the Americas, China, Japan, and Africa.

In writing this book, I have been influenced by numerous studies, including detailed general works, specialized monographs, and theoretical studies. Initially, the most informative were Niels Luning Prak's *The Language of Architecture* (The Hague, 1968) and Steen Eiler Rasmussen's classic *Experiencing Architecture* (Cambridge, MA, 1959; 2nd ed., 1962). Other influential sources are listed in the Suggested Readings for each respective chapter.

A historical survey such as that found in Part II cannot help but be influenced by Nikolaus Pevsner's *An Outline of European Architecture* (Harmondsworth, England, 1943; 7th ed., 1963), which, despite its date, is still in print and considered one of the most important books of its kind. Many other broad and comprehensive histories have followed—but, unlike those encyclopedic surveys, the present compact book examines architecture as a cultural expression and focuses on selected examples or case studies as types rather than trying to trace in detail the chronological intricacies of historical development.

Whatever I may have absorbed from reading all these studies was modified and enlarged in the classroom. And I must acknowledge, too, the contributions made by my students over the years through their questions, expressed both verbally and in furrowed brows. It is impossible to thank adequately my professional colleagues, who offered comments in their areas of expertise; my special gratitude is extended to Professors G. Z. Brown, Deborah Hurtt, Jeffrey Hurwit, Charles Lachman, Andrew Morrogh, John Reynolds, Richard Sundt, and Akiko Walley.

A word should also be said about the plans illustrated throughout the book, for here, too, students contributed significantly. Aside from those drawings that I prepared myself, many others were

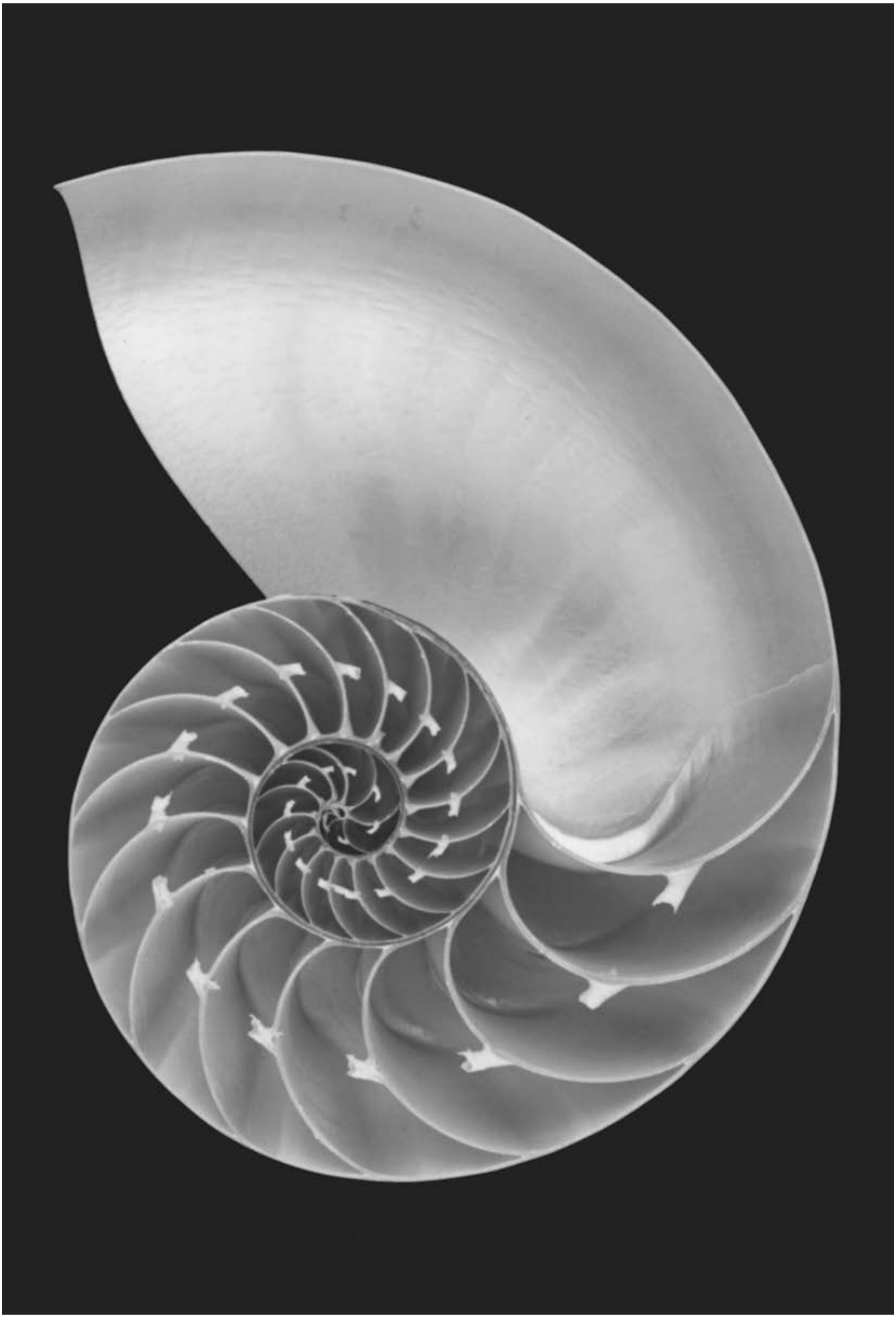
drawn to uniform conventions by architecture students in several special media courses that I taught during 1985–1986. The students are individually identified in the List of Illustrations.

For more than a quarter-century, my writing and publishing endeavors were greatly encouraged by Cass Canfield Jr., my original editor at Harper & Row and then HarperCollins. He provided boundless support and initiated both the first and second editions. Following a transfer of HarperCollins' collegiate text division to Westview Press, the second edition was completed under new editors Sarah Warner, and then Steve Catalano and Cathleen Tetro, who were especially supportive.

The impetus for this third edition was a request by Priscilla McGeehon, but following her departure from Westview the project was taken up with great enthusiasm and support by Cathleen Tetro. One important initial undertaking was to engage long-time editor Marcus Boggs as the initial reader and critic who provided me with invaluable advice and encouragement. A book like this, with its many illustrations, entails the help of numerous individuals, and they deserve particular thanks. Among them are Stephen Pinto at Westview/Perseus, who directed the final production of the book; Trish Wilkinson, who designed this new edition; Sue Howard, who located many of the new images; and Cisca L. Schreefel, Christine J. Arden, and the many others whose dedication to the details of producing this book is acknowledged with grateful appreciation.

Special thanks are due to Carol, who sustains me always, who read the drafts of the earlier editions with a critical eye, and who painstakingly, analytically, and dispassionately read this third edition, ensuring the logical and graceful continuity of each chapter. And a unique thanks must be rendered to Amanda, to whom, when an infant, my books were first dedicated. Now grown, and having started on a life's career in the history of the visual arts, she has co-written the most recent changes in the book with me, bringing to it the benefits of her perspective as a student, teacher, critic, and, now, colleague.

Leland M. Roth
Eugene, Oregon



2. Section view of the shell of a chambered nautilus. The nautilus shell, incrementally built by means of an unconscious biological process, is the record of the life of its inhabitant. Photo: L. M. Roth.

Introduction

> Architecture is what nature cannot make.
>
> —*Louis I. Kahn*

Architecture is generally something people take for granted, moving toward it, around it, through it, using it without a thought. It is simply there, an unassuming backdrop, a mute, utilitarian container. Architecture is much more, however; it is the crystallization of ideas. It has been defined many ways—as shelter in the form of art, a blossoming in stone and a flowering of geometry (Ralph Waldo Emerson), frozen music (Goethe), human triumph over gravitation and the will to power (Nietzsche), the will of an epoch translated into space (architect Ludwig Mies van der Rohe), the magnificent play of forms in light (architect Le Corbusier), a cultural instrument (architect Louis I. Kahn), and even inhabited sculpture (sculptor Constantin Brancusi). More recently, architectural critic Ada Louise Huxtable framed a rather clinical definition, calling architecture a "balance of structural science and aesthetic expression for the satisfaction of needs that go far beyond the utilitarian."[1]

Architecture is the unavoidable art. Almost every moment of our lives, awake or asleep, we are in buildings, around buildings, in spaces defined by buildings, or in landscapes shaped by human artifice. It is possible to deliberately avoid looking at paintings, sculpture, drawings, or any other visual art, but architecture constantly touches us, shapes our behavior, and conditions our psychological mood. The blind and deaf may not see paintings or hear music, but they must deal with architecture. Moreover, aside from being shelter or a protective umbrella, architecture is also the physical record of human activity and aspiration; it is the cultural legacy left to us by all preceding generations.

The architect Louis I. Kahn wrote that "architecture is what nature cannot make."[2] Humans are among several animals that build, and indeed some structures built by birds, bees, and termites, to name but a few, demonstrate human-like engineering skill in their economy of structure. One particular bird, the rufous-breasted castle builder of South America, weaves two chambers connected by a cantilevered tube between the two, creating a double-chambered nest in the form of a dumbbell [1]. Certain blind termites build soaring arches of mud, starting at two distinct springing points, pushing their sections upward until they meet in the air.[3] Mollusks, such as the chambered nautilus, construct their protective houses around them, creating a hard shell of calcium carbonate [2, facing page]. As the nautilus grows, it adds a new and somewhat larger chamber to its curved shell, the vacated chamber then being filled with nitrogen gas to add buoyancy to the enlarged mass; the older parts of the shell, however, remain as a record of the history of the animal. Architecture is the chambered nautilus shell of the human species; it is the environment that we build for ourselves, and that, as we grow in experience and knowledge, we change and adapt to our expanded condition. If we wish to understand ourselves, we must take care not to eliminate the "shell" of our past, for it is the physical record of our aspirations and achievements.

It was once customary to think of architecture as consisting only of those buildings that we deemed important, the great church and state buildings that involved substantial expenditure of energy and funds. Perhaps this viewpoint came about because, in past centuries, histories of architecture were written largely by architects, princely patrons, or court historians who wished to sharpen the distinction between what they had achieved and the surrounding mass of vernacular buildings. In his compact *Outline of European Architecture,* first published in

1. Nest of the South American rufous-breasted castle builder. This nest exemplifies deliberate construction in the animal kingdom, largely driven by genetic programming. From P. Goodfellow, Birds as Builders *(New York, 1977).*

1943, Nikolaus Pevsner began by making the distinction that "a bicycle shed is a building; Lincoln Cathedral is a piece of architecture" [3, 4].[4] Conventional wisdom often makes the same distinction, as demonstrated in this now-folkloric story: A metal-building manufacturer who made barn structures offered buyers a wide choice of historically themed clip-on door frames as embellishment—American Colonial, Mediterranean, and Classical, among many others. After a severe windstorm damaged many barns in one area, the factory representative telephoned customers to find out how the structures had fared. One customer, whose Colonial door frame had been stripped off while the barn itself survived, replied, "The building's fine but the architecture blew away."[5]

We cannot, however, focus solely on the "Architecture" of Lincoln Cathedral or Notre-Dame in Amiens, France, or any medieval cathedral, for that matter, without taking into account the scores of "mere buildings" among which it sits. If we ignore all the humble houses that made up the city around the massive cathedrals, we would misinterpret the position occupied by the church in the social and cultural context of the Middle Ages, and we would forget all the townspeople and local artisans who had built them.

We must consider both the "architecture" and the "buildings," the cathedral and the ordinary houses surrounding it, for all the buildings as a group constitute the architecture of the Middle Ages. So, too, if we wish to understand the totality of the architecture of the contemporary city, we must consider all its component elements. For example, to understand Eugene, Oregon, we would need to examine the bicycle sheds and the bus transfer shelters that are an integrated part of the public transportation system. In this city, bicyclists can lock their bikes under a roof and transfer to motorized public transit. The bicycle sheds are part of a municipal ecological response, an effort to enhance the physical living environment by encouraging modes of transportation other than private automobiles.

Pevsner's emphatic distinction between architecture and building is understandable, considering the limits of his compact book, for it made the material he needed to cover more manageable. His view grew out of the extended influence of the nineteenth-century critic John Ruskin, who made the same distinction in the second sentence of his book, *The*

3. Lane Transit District Bicycle Shed, Eugene, Oregon,1984. Far from being an undistinguished shed, the bicycle cover here is part of a citywide network of shelters designed to encourage the use of bus transportation. Photo: L. M. Roth.

Seven Lamps of Architecture (London, 1849): "It is very necessary, in the outset of all inquiry," wrote Ruskin, "to distinguish carefully between Architecture and Building." Ruskin wanted to concentrate his attention on religious and public buildings, but at the same time he recognized that architecture was a richly informative cultural artifact. In another of his many writings, the Preface to *St. Mark's Rest* (London, 1877), he cautioned that "great nations write their autobiographies in three manuscripts—the book of their deeds, the book of their words, and the book of their art. Not one of these books can be understood unless we read the other two; but of the three, the only quite trustworthy one is the last."[6] As Ruskin correctly recognized, to understand the architecture of the past, of any period or culture not our own, we must absorb the history and literature of that period and place, the record of its acts and thoughts, before we can understand fully what message the architecture conveys. Architecture, then, is like written history and literature—a record of the people who produced it—and it can be "read" in a comparable way. Architecture is a nonverbal form of communication, a mute record of the culture that produced it.

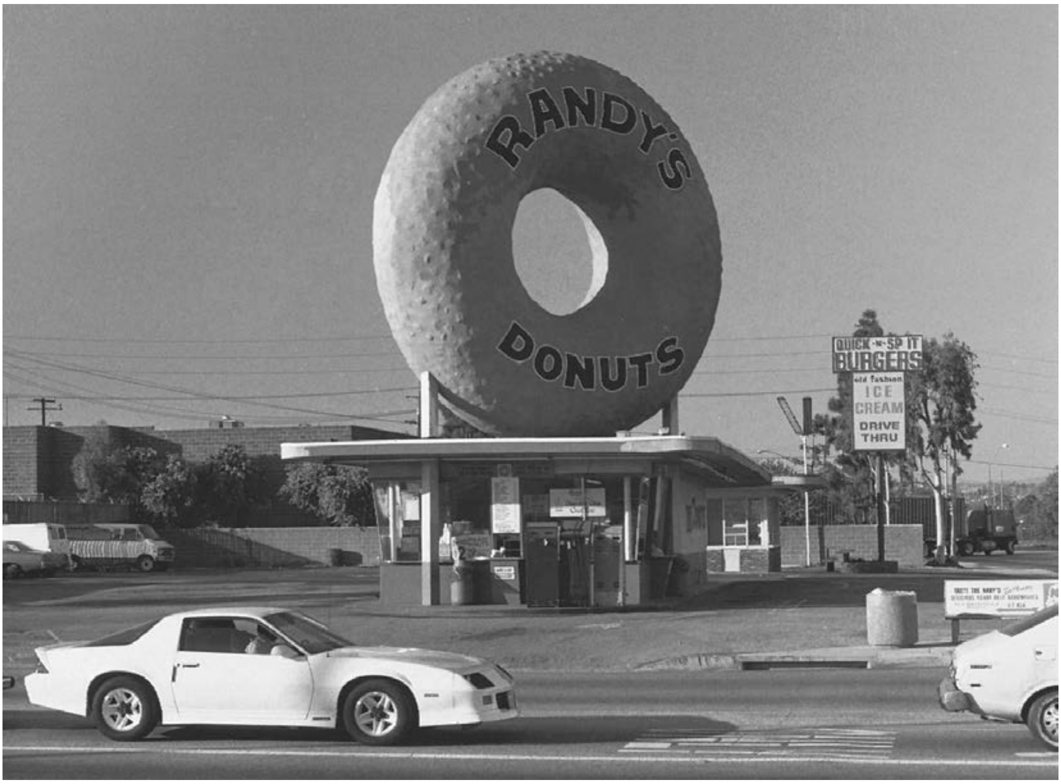
These ideas—the totality of the built environment as architecture, and the environment as a form of dialogue with the past and future—underlie this book. Architecture is understood to be the whole of the human-built environment, including buildings, cities, urban spaces, and created landscapes. And while it is not possible in a book of this size to examine in detail all types of buildings in all ages, the reader needs to keep in mind the idea that the broad spectrum of building of any period, and not just a few special buildings, constitutes its architecture.

Building is a conscious act that embodies countless reflective, evaluative choices. These choices are what distinguish human building from birds' nests and beehives, for these animals build as the result of genetic programming. It could be said, as a counterargument, however, that male bower birds build their elaborate courting enclosures by making deliberate choices of what colorful or light-catching embellishments to add. Humans also build to satisfy a felt need, but even as they do so, they give expression

4. Lincoln Cathedral, Lincoln, England, 1192–1280. This building was constructed as a public demonstration of both church power and civic pride. Photo: Edwin Smith, London.

to feelings and values; they are expressing in wood, stone, metal, plaster, and plastic what they believe to be vital and important, whether it is a bicycle shed or a cathedral. It may be a message clearly understood and deliberately incorporated by both client and architect, or it may be an unconscious or subconscious statement, decipherable by a later observer. Hence, the US Capitol in Washington, DC, has as much to tell us about the symbolism of republican government in the nineteenth century as the World Trade Center in New York City once told us about American capitalism and soaring urban land values in the twentieth century. But equally important as a cultural artifact and as architecture is the Big Donut Shop in Los Angeles, built in 1954 by Henry J. Goodwin [5], for it reflects Americans' love of the private automobile and their desire for instant alimentary gratification.

Architecture is the unavoidable art. We deal with it every waking moment when not in the wilderness; it is the art form we inhabit. Perhaps this familiarity causes us to think of architecture as only a utilitarian agent, as simply the largest of our technical contrivances, requiring of us no more thought than any other appliance we use throughout the day. And yet, unlike the other arts, architecture has the power to affect and condition human behavior; the color of walls in a room, for example, can help determine our mood. Architecture acts on us, creating in some buildings a sense of awe such as one might feel while walking among the huge stone columns of the hypostyle hall of



5. Henry J. Goodwin, Big Donut Shop, Los Angeles, California, 1954. Photo: L. M. Roth.

the Egyptian temple at Karnak [p. 186]; or being pulled forward, as if by gravity, to the center of the vast space covered by the dome of the Pantheon in Rome; or sensing the flow of space and a connection to the earth as in Frank Lloyd Wright's Fallingwater [1.8, 4.24, 10.21].

Part of our experience of architecture may be based largely on our innate enjoyment of these physiological responses—which the skillful architect knows how to manipulate to maximum effect. But the fullest experience of architecture comes from expanding our knowledge of a building, its structure, its history, and its meaning, while reducing our prejudices and ignorance.

We should remember, too, that architecture, besides providing shelter, is symbolic expression. As Sir Herbert Read wrote, art is "a mode of symbolic discourse, and where there is no symbol and therefore no discourse, there is no art."[7] This symbolic content is most easily perceived in religious and public buildings, where the principal intent is to make a broad and emphatic proclamation of communal values and beliefs. If a building seems strange to someone, it is likely because the symbol being presented is not in that person's vocabulary. To those of us who have no Gothic architectural heritage, the reconstruction of the Houses of Parliament in London in the mid-nineteenth century in the medieval Gothic style might seem at first puzzlingly anachronistic. Yet it becomes more understandable when we remember that actual Gothic buildings were to be incorporated into the new Parliament complex and, more importantly, that Gothic architecture was perceived by nineteenth-century Englishmen as inherently English and thus had a long connection with parliamentary government. The argument could be made that, for them, Gothic was the *most* appropriate style.

Architecture is the science and the art of building. To understand more clearly the art of architecture and its symbolic discourse, we are best served by first gaining an understanding of the science of architectural construction. So, in the following chapters of Part I, the pragmatic concerns of space, function, structure, and design are explored. Then, in Part II, the symbolism of architecture as a nonverbal means of discourse is taken up. Interspersed throughout are six brief essays on world architecture, placed within the text where intersections between differing traditions are discussed.

Stonehenge, 2600–2400 BCE. Salisbury Plain, Wiltshire, England. One of the trilithons ("three stones"), with uprights standing 13 feet high, emblematic of the essence of architectural construction. Photo courtesy of Marian Card Donnelly.

Part I

The Elements of Architecture

1.12. Salisbury Cathedral nave, Salisbury, England, 1220–1266, Interior, nave. The repeated bays and strong horizontal layering draw the eye strongly along the axis, illustrating directional space. Photo: Anthony Scibilia/Art Resource, NY.

Architecture

The Art of Shaping of Space

The history of architecture is primarily a history of man shaping space.

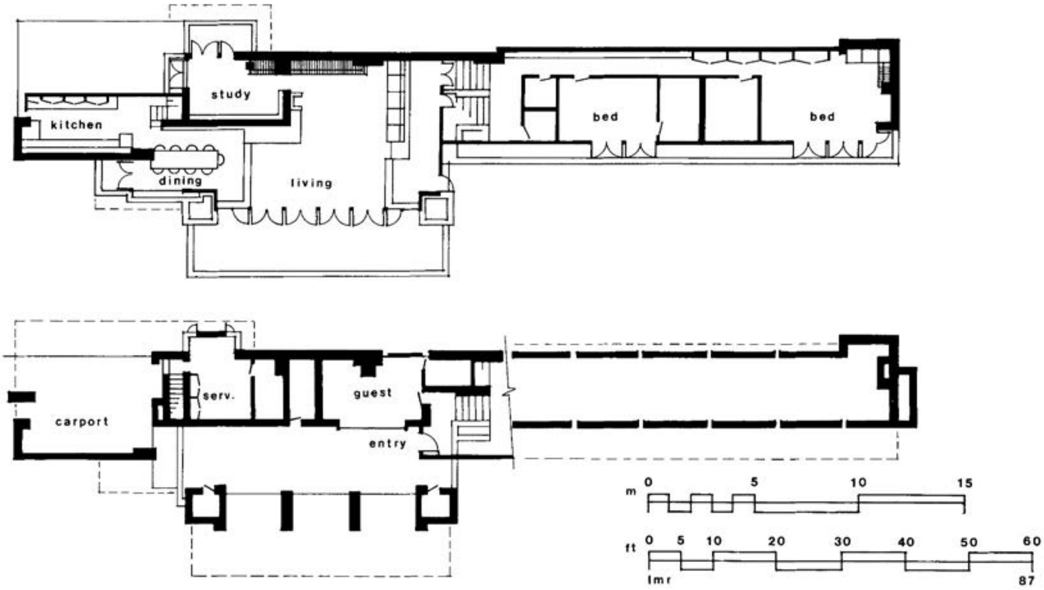
—*Nikolaus Pevsner,* An Outline of European Architecture, *1943*

Today, at the dawn of the twenty-first century, digital artists can create a virtual image of the inside of a building. This is a most useful operation, suggesting what a building will be like long before costly construction is begun. But the total physiological, kinesthetic, sensory, and psychological experience is missing. Architecture must be experienced by walking around and into it.[1]

Architecture is the art into which we walk, the art that envelops us. Besides making a distinction between "architecture" and "building"—a concept with which there might be disagreement—Nikolaus Pevsner's further observation that architecture is the shaping of space is undisputed.[2] As he notes, painters and sculptors affect our senses by creating changes in patterns, and in proportional relationships between shapes, through the manipulation of light and color, but only architects shape the space in which we live and through which we move. Frank Lloyd Wright believed space was the essence of architecture and, early in his career, discovered that the same idea had been expressed centuries earlier by Laozi (Lao-Tse) and paraphrased in 1906 by Okakura Kakuzo in *The Book of Tea*. The reality of architecture, Kakuzo observed, lay not in the solid elements that seem to make it but in the empty space defined by those elements: "The reality of a room, for instance, was to be found in the vacant space enclosed by the roof and walls, not in the roof and walls themselves. In just the same way, the usefulness of a water pitcher dwelt in the emptiness where the water might be put, not in the form of the pitcher or the material out of which it was made."[3]

The architect manipulates space of many kinds in many ways. There is first the purely ***physical space***, which can be imagined as the volume of air bounded by the walls, floor, and ceiling of a room. This can be easily computed and expressed as so many cubic feet or cubic meters. But there also is ***perceptual space***—the space that can be perceived or seen. Especially in a building with walls of glass, this perceptual space may extend well beyond the boundary of the glass and may be impossible to quantify. Related to perceptual space is ***conceptual space***, which can be defined as the mental map we carry around in our heads, the plan stored in our memory. We navigate through our house, workplace, or community by referring to our mental map of its conceptual space. Buildings that work well are those whose plans and spatial arrangements can be easily grasped and held by users in their mind's eye and through which they can move about easily with a kind of inevitability; such buildings can be said to have clear conceptual space. The architect can also decisively shape ***behavioral space***, or the space we actually move through and use. Behavioral space can be imagined as a clearly defined room with four walls, a ceiling, and a floor—an easily calculated volume. But now picture a large hole that has been cut into the floor, with the opening covered by a cloth. The physical space has not changed at all, but a person now must walk around the periphery of the room instead of diagonally across it. The behavioral space has been changed.

All the types of space just mentioned can be illustrated by examining the Lloyd Lewis House in Libertyville, Illinois, 1939, by Frank Lloyd Wright [1.1]. From within the living room, as we look toward the fireplace, the view is defined by the built-in bookcases, the brick of the fireplace mass, the floor, and the ceiling [1.2]. All the surfaces are opaque and suggest a clear sensation of confinement and protection; the physical space is evident. As we look left, however, the view stretches out through a



1.1. Frank Lloyd Wright, Lloyd Lewis House, Libertyville, Illinois, 1939. Plans of the lower level and the upper living level. Drawing: L. M. Roth.

1.2. Lloyd Lewis House. View of the living room, looking toward the fireplace; from this vantage point, the space is sharply defined and suggests comforting enclosure. Photo by Hedrich Blessing. Chicago History Museum, negative HB-19240-C.

1.3. Lloyd Lewis House. View of the living room, looking toward the screen of French doors; from this direction, a person's view can pass into the countryside, into a large perceptual space. Photo by Hedrich Blessing. Chicago History Museum, negative HB-06485I.

broad bank of glazed French doors to the meadow and woodland beyond [1.3]. From this vantage point, the perceptual space reaches out across the field and to the sky, as far as the eye can see. Moving toward the dining area, we see the built-in dining table, fastened to a brick pier [1.4]. To move from the living room through the dining area and into the kitchen, we must move around that built-in table, since it cannot be moved. In purely physical terms, the table takes up very little volume, a very few cubic feet compared to the many hundreds of cubic feet in the combined living and dining space, but in behavioral terms, it determines in a decisive way how we can move about in that space.

Architectural space, in all its various forms, is a powerful determinant of behavior. Winston Churchill understood this well when he addressed the House of Commons in 1943, noting that first "we shape our buildings, and afterwards our buildings shape us."[4] What prompted his observation was a debate on rebuilding the severely burned House of Commons. The chamber in which the Commons had been meeting for nearly a century was gutted by a German bomb in 1941, and Parliament was considering alternative ways of reconstructing the chamber. When Parliament had first begun to meet in the thirteenth century, it had been given the use of rooms in medieval Westminster Palace and had occupied the palace chapel. A typical Gothic chapel, it was narrow and tall, with parallel rows of choir stalls facing each other on either side of an aisle down the center. The members of Parliament sat in the choir stalls, dividing themselves into two groups: on one side the government in power and on the other the loyal opposition. Seldom did members take the brave step of crossing the aisle to change, and hence visibly declare, their new political allegiance. When the Houses of Parliament had to be rebuilt after the catastrophic fire of 1834, the old Gothic archetype had been followed, and Churchill argued that this ought to be done again in 1943. There were those who advocated rebuilding

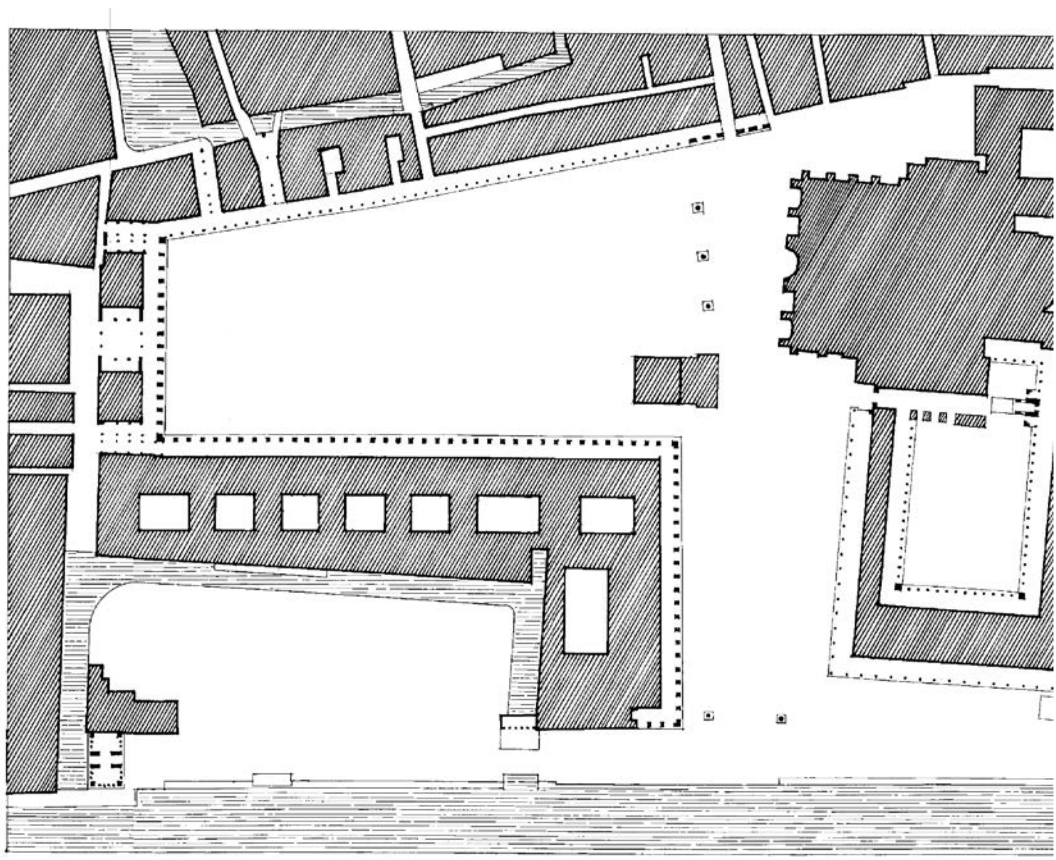
1.4. Lloyd Lewis House. View of the dining area, showing the built-in table; the fixed table clearly determines how a person is directed through this space, thereby determining behavior. Photo by Hedrich Blessing. Chicago History Museum, negative HB-06485i.

the House with a fan of seats in a broad semicircle, as used in legislative chambers in the United States and France. But Churchill convincingly argued that the essence of English parliamentary procedure had been permanently shaped by the physical environment in which it had first been housed: to so fundamentally change that environment, to give it a different behavioral space, would be to change the very nature of parliamentary discourse and government. The English had first shaped their architecture, he said, and that architecture in turn had shaped English government and history. Through Churchill's persuasion, the Houses of Parliament were rebuilt with the old arrangement of parallel seats looking across a central aisle [1.5].

These concepts of *physical, perceptual,* and *behavioral* space have been applied here to spaces within individual buildings. With slight redefining, such terms can be used to describe experiences in large outdoor spaces as well. Consider the huge outdoor living room in Venice—the Piazza di San Marco [1.6, 1.7]. From the middle of the piazza as one looks west, the space is clearly defined and enclosed by the walls of the buildings on either side and straight ahead. Much the same is true if one turns around and faces east, toward the Church of San Marco, but with this perspective the light coming from the right gives a hint of an opening. Moving eastward, approaching the front of the church, one must move around the soaring tower of the Campanile, which stands in the piazza and determines one's walking behavior. Once around the Campanile, one sees the smaller piazzetta, which extends toward the south. Past the pair of freestanding columns that mark the boundary of the piazzetta, one's view crosses the canal, and the enclosed physical space opens up in a virtually boundless perceptual space.

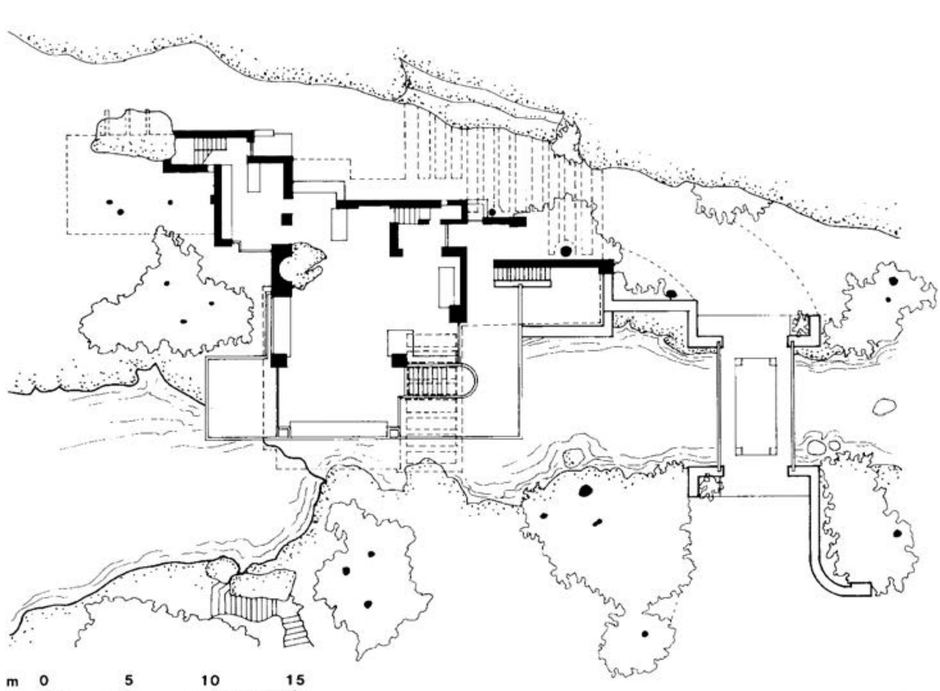
The plan of the Lloyd Lewis House also illustrates clearly the possibility of fluidity of space—***interwoven spaces*** as contrasted with ***static spaces***. Wright was a master of interweaving connected spaces, creating what has been described as fluid or flowing spaces, beginning in his Prairie Houses of 1900 to 1910 and continuing in Fallingwater, near Mill Run, Pennsylvania, built for the Kaufmann family in 1936–1938 [1.8]. In these houses, there is no isolation of the living and dining rooms or the library alcove; all are loosely defined as component areas of a larger fluid space. Wright developed this

1.5. Sir Charles Barry and A. W. N. Pugin, House of Commons chamber, Houses of Parliament, London, England, 1836–1870; restored 1946. Following extensive damage after being hit by a German bomb, the House of Commons chamber, an example of the impact of behavioral space, was rebuilt at the urging of Winston Churchill nearly exactly as it had been, since to have changed it, he argued, would change the operation of parliamentary governance. Photo: © Richard Bryant/Arcaid/Corbis.



1.6. Piazza di San Marco, Venice, Italy, 830–1640. Plan of piazza. Drawing: L. M. Roth.

1.7. Piazza di San Marco. This exterior enclosure contains aspects of physical, perceptual, and behavioral forms of space. Photo: © Yann Arthus-Bertrand/Corbis.

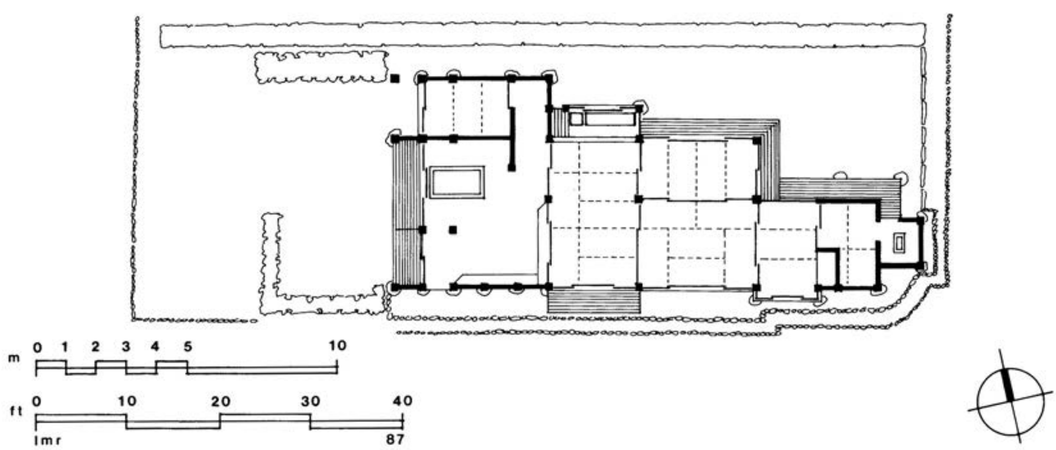


1.8. Frank Lloyd Wright, Edgar Kaufmann residence, Fallingwater, near Mill Run, Pennsylvania, 1936–1938. Plan. Here space is molded in a fluid way; it opens out through the banks of glass on the south to the wooded ravine. Drawing: M. Burgess and L. M. Roth.

1.9. Shokin-tei (Pine-Lute Pavilion), Imperial Villa of Katsura, near Kyoto, Japan, 1645–1649. View from inside the pavilion out toward the Middle Islands. This view indicates the sense of difference between internal enclosed space and the expanding external space in the garden. Photo from: Akira Naito, Katsura: A Princely Retreat *(Tokyo, 1977).*

conception of space as a result of studying Japanese architecture. In the traditional Japanese house, a wooden structural frame supports rails along which screens slide. These screens define the "rooms" of the Japanese house by being closed, or they permit the house to be opened up by being pushed back [1.9, 1.10, Plate 1]. In the traditional Japanese house, there are no solidly enclosed rooms in the conventional Western sense. The influence of Wright's earlier decompartmentalized Prairie House plans on European architects is illustrated in Ludwig Mies van der Rohe's German Pavilion for the international exposition held in Barcelona in the summer of 1929 [19.20]. There are no rooms in the ordinary Western sense here, either, but rather a series of planes arranged in space, capable of defining a group of interrelated areas.

Conversely, more traditional European or American houses of the turn of the century were subdivided into discrete rooms, each intended to accommodate a clearly understood function: for lounging, dining, reading, receiving guests, and so forth. One example is the William F. Fahnestock House at Katonah, New York, 1909–1924 (now demolished), by Charles A. Platt, with its cluster of individual rooms [1.11]. This was similar in many ways to Platt's Harold F. McCormick House in Lake Forest, Illinois, 1908–1918. Originally, a different house had been designed for the McCormicks in 1908 by Frank Lloyd Wright (it would have been



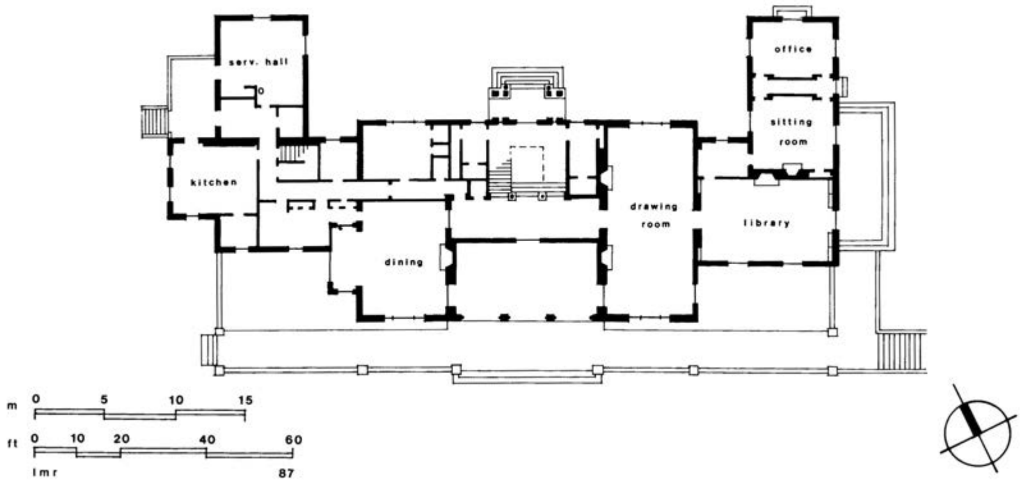
1.10. Shoi-ken (Laughing Thoughts Pavilion), Imperial Villa of Katsura, 1645–1649. Plan. The plan arrangement, based on the module of the tatami floor mat, and the use of sliding wall screens, allows for many spatial arrangements. Drawing: L. M. Roth.

his largest Prairie House ever), and in it, he devised a number of broad, interwoven spaces that opened up and flowed into one another. As it happened, Mrs. Edith McCormick wanted a more formal and traditionally compartmentalized lifestyle, and for that, Platt's compartmentalized plan proved more suitable.

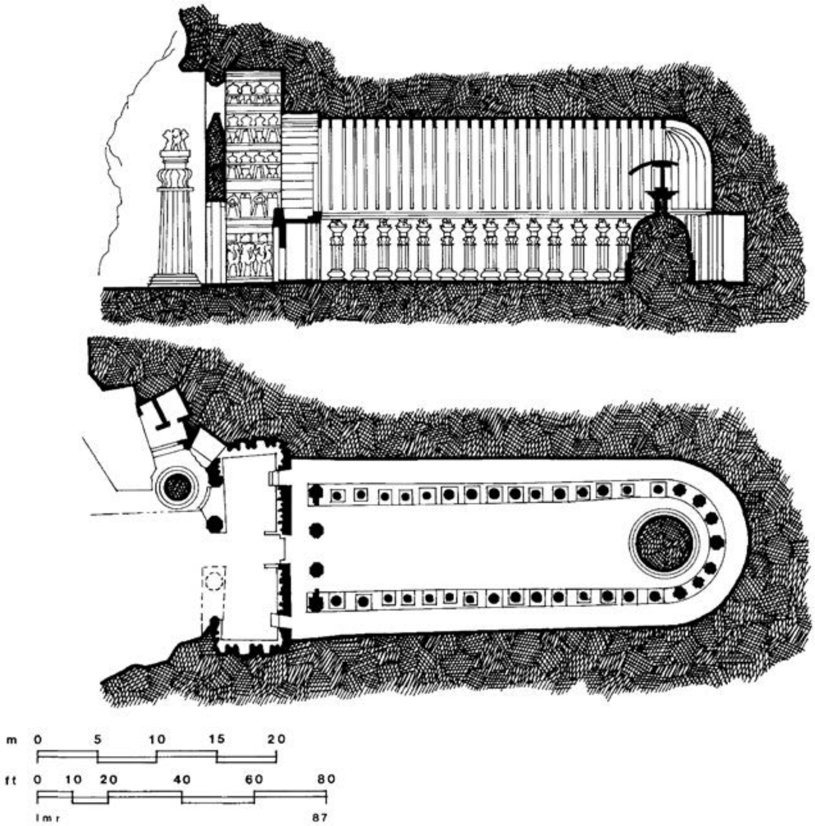
Space can determine or suggest patterns of behavior by its very configuration, regardless of barriers or hindrances. We speak of ***directional space***, as distinct from ***nondirectional space***. The plan of the German Pavilion at Barcelona effectively illustrates nondirectional space, for there is no one obvious compelling path through the building but, rather, a variety from which to choose [19.21]. In contrast, in a Gothic cathedral, the emphatic axis directs movement toward the single focus—the altar at the end [1.12, see p. 8]. This gravitational pull seems especially strong in English cathedrals, such as the cathedral at Salisbury, with its superimposed and emphasized horizontal lines creating a strong visual focus on the altar in the distance.

We can speak, too, of ***positive*** and ***negative space***. A positive space is one that is conceived as a void, then wrapped in a built shell specifically erected to define and contain it. One example would be the plaster interior shell of the pilgrimage church of Vierzehnheiligen (Fourteen Saints), in the countryside of Franconia, southern Germany, 1742–1772, by Johann Balthasar Neumann [16.45, p. 414]. There is nothing structurally substantial about this suspended plaster shell; it is there solely as an envelope to define a particular space and shape a particular architectural and religious experience. In contrast, we can speak of negative space, created by hollowing out a solid that already exists. The earliest ready-made habitations of the human species may have been naturally hollowed-out caves, memories of which linger in such rock-cut caves as those at Ajunta and Karli, India, carved out from 2000 BCE through 650 CE [1.13].[5] In these cave temples, the space was created by laboriously cutting away the existing solid rock to create the desired void, often leaving columns and vaults that resemble buildings built of wood.

The concepts of positive and negative space can be applied in a somewhat analogous way to urban space as well. In this context, negative space might be defined as open space that is simply left over after the construction of surrounding buildings, but positive urban space would then be defined as deliberately and abstractly conceived and constructed in accordance with a preconceived plan. These two differing ideas can be seen in the city of Florence, Italy. The major public space, the Piazza della Signoria, is in front of the principal municipal building, the medieval Palazzo Vecchio, 1298–1310, which juts out into the irregularly shaped open space [1.14]. The irregular Piazza della Signoria, given shape as disparate buildings were erected over several centuries, could be described as a resultant negative space. However, as the Renaissance developed in Florence during the following century, an entirely new attitude toward space and its definition arose there—a notion of space closely related to the invention of mathematical perspective in painting and to the grid concept being used in contemporaneous mapmaking. In 1419, when Filippo Brunelleschi



1.11. Charles A. Platt, William F. Fahnestock House, Katonah, New York, 1909–1924 (demolished). In this residence the spaces are clearly compartmentalized for separation of activities and for acoustical privacy. Drawing: L. M. Roth.

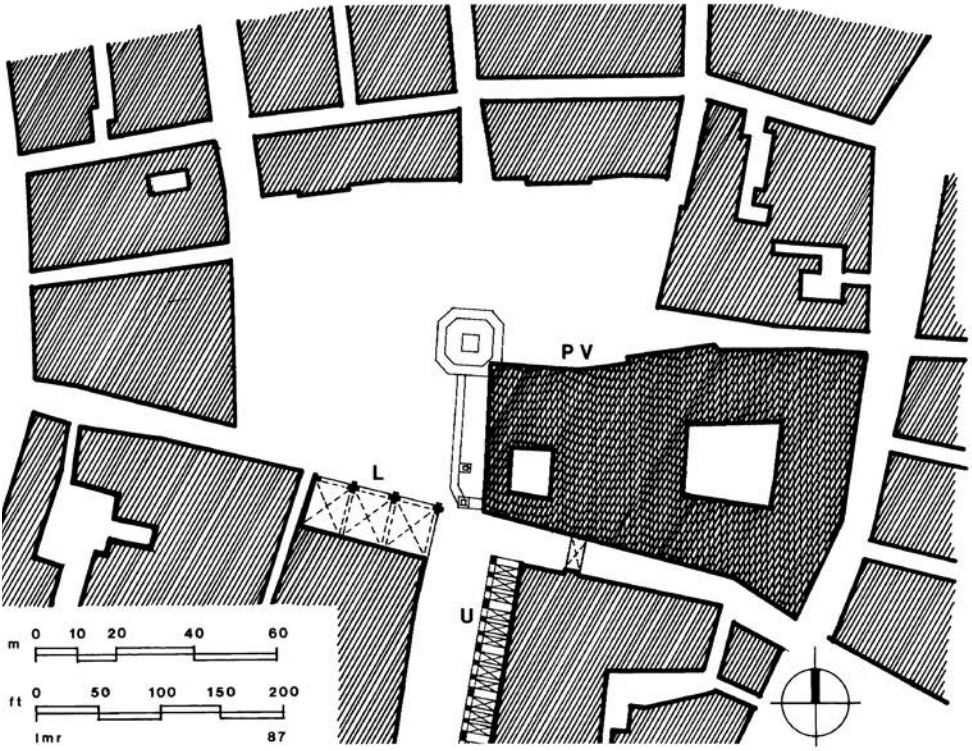


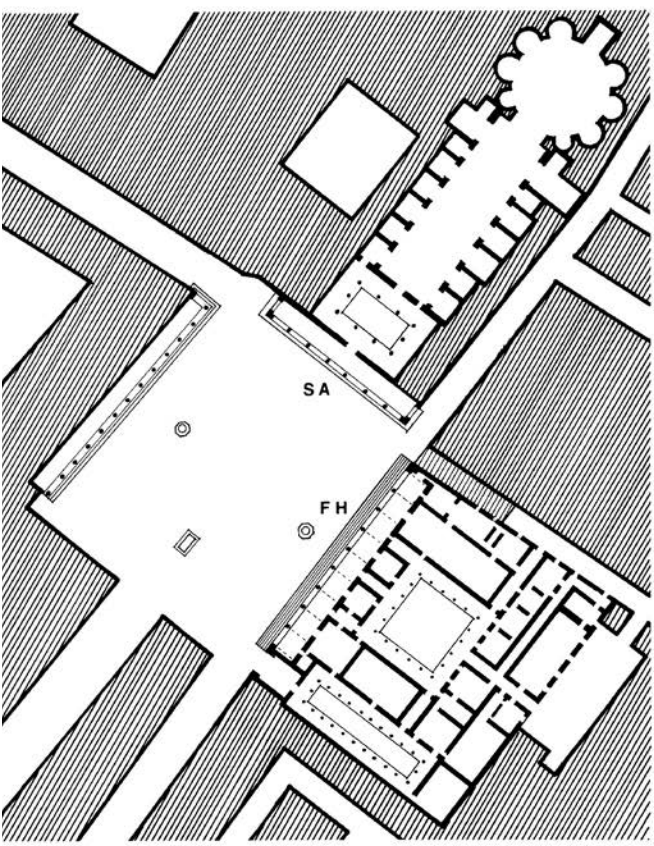
1.13. Cave temple, Karli, India, c. 100 CE. Plan and section. This example of "negative space" was created by hollowing out the solid rock of the cliff, leaving columns and a vaulted chamber inspired by traditional wooden architecture. Drawing: L. M. Roth, after Susan and John Huntington, The Art of Ancient India *(New York, 1985).*

designed his Ospedale degli Innocenti (Foundling or Orphans Hospital) about half a mile north of the Piazza della Signoria, he divided the facade into a row of identical square arcade modules. The space in front of the hospital was then opened up into an urban square, the Piazza Annunziata, and the architects of all the surrounding subsequent buildings based their facades on the Brunelleschian arcade module. The result was that the piazza became an orderly rectangle governed by an implied mathematical grid that seems to determine the placement of every part of its defining walls [1.15 and 15.7]. The Piazza Annunziata could be described as a positive space, defined in accordance with preconceived geometric ideas.

There is still another social way of defining space, and although it might not be thought of as strictly architectural, the architect nevertheless is well advised to take it into account. This is ***personal space***, the distance that members of a particular species naturally and automatically put between themselves. This is illustrated by the way birds space themselves along the ridgeline of a building or on a telephone wire, or by the way humans space themselves when resting on a bench in a shopping mall [1.16].[6] For most animals, this zone of comfort is genetically programmed. On rocky coastal outcroppings, seals and walruses heap themselves on top of each other in apparent bliss, while swans and hummingbirds generally take great care to avoid contact with or close proximity to others of their kind. Experiments in which animals are forced to exist in crowded conditions, in conflict with their internal genetically programmed code, can produce seriously aberrant behavior.

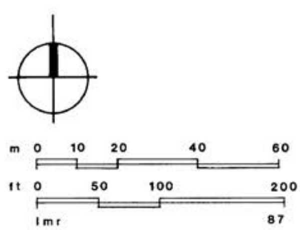
Humans, however, have proven themselves to be extremely flexible in their determination of personal space; they seem not to have any particular programmed genetic spatial code; or perhaps humans train themselves to ignore biological alarms. Instead, among humans, personal space is culturally determined and is largely fixed in childhood,





1.14. Piazza della Signoria, Florence, Italy, 1298–1310. This "negative urban space" developed out of what was left after the construction of the surrounding buildings. **L** *= Loggia della Signoria (Loggia dei Lanzi);* **PV** *= Palazzo Vecchio;* **U** *= Uffizi (municipal offices). Drawing: L. M. Roth.*

1.15. Filippo Brunelleschi and others, Piazza Annunziata, Florence, Italy, begun 1419. This "positive urban space" was deliberately planned in conjunction with the modular facade of Brunelleschi's Foundling Hospital. **FH** *= Founding Hospital (Ospedale degli Innocenti);* **SA** *= Santa Annunziata. Drawing: L. M. Roth.*



1.16. An example of personal space. This photo taken in Toronto (at the Eaton Centre shopping mall) clearly indicates the degree of acquaintance between individuals. While the young couple snuggle together closely, the other disparate adults keep as much distance between each other as is possible on this crowded bench. Photo courtesy of photographer John Ferri, from his 2011 photo series "Bench."

so that later in life, enforced changes in personal distance may produce severe anxiety. Typically Italians and the French prefer much more densely packed social arrangements, as in the seating in outdoor cafés, than do northern Europeans, Americans, or the English. Asians, however, customarily place themselves in extremely dense congregations. Even within the same culture, however, different sets of rules are adopted by males and females. Two unacquainted men will maintain a greater distance than will two unacquainted women, particularly in the United States. If an architect should happen to violate these unstated dimensions of personal space—for example, by placing workers in an office arrangement too close together, even if every other architectural variable is optimized—the result may be an environment that is resisted by the users and hence detrimental to the entire business operation.

Failure to understand these nuances of personal space and similar cultural factors creates a particular risk when an architect is designing for users belonging to a culture or social group to which he or she does not belong. This problem was vividly demonstrated by the design of the Pruitt-Igoe public housing of Saint Louis, Missouri, 1952–1955. This housing had been designed by well-intended, well-trained middle-class architects for very low-income residents but was done in such a way that its inhabitants could not visually supervise either the public spaces or the hallways in their long apartment blocks. The designers had little or no idea of how the intended residents might use (or misuse) the buildings. As a result, muggings steadily increased once the complex was occupied. In growing numbers, prospective residents simply began refusing to live there. Eventually, the housing proved so hazardous to inhabit that the city destroyed it in 1972 [19.56].[7]

In short, architects must think in terms of space: the space around and outside of a building, the space that people walk through when moving inside a building, the "borrowed perceptual space" that they can see but perhaps not directly access, the behavioral impact of that space, and the personal spatial interval that people desire to have between each other. The shaping of usable space is the primary function of architecture.

2.5. Adler & Sullivan, Wainwright Building, Saint Louis, Missouri, 1890–1891. The arrangement of the parts of this office building clearly expressed the differing functions of the parts of the building, effectively demonstrating what Sullivan meant when he wrote later that "form ever follows function." Photo by Hedrich Blessing. Chicago History Museum, negative HB-19240-C.

Chapter 2

"Commoditie"
Building Functions

Haec autem ita fieri debent, ut habeatur ratio firmitatis, utilitatis, venustatis. (Now these [aspects of building] should be so carried out that account is taken of strength, utility, grace.)

—*Marcus Vitruvius,* De Architectura, *c. 25 BCE*

In architecture as in all other operative arts, the end must direct the operation. The end is to build well. Well-building hath three conditions: Commoditie, Firmeness, and Delight.

—*Sir Henry Wotten,* The Elements of Architecture, *1624*

The basic definition of architecture framed by the ancient Roman architect Marcus Vitruvius Pollio (c. 90–c. 20 BCE), in about 25 BCE, has never been improved upon. However, Vitruvius noted that architecture had been the subject of critical writing long before his time. Several Greek architects compiled books on their profession during the centuries before the Common Era, leading up to the text written by Vitruvius. He listed sixty-three Greek and Roman books on architecture that he consulted, some dating back to the fourth century BCE.[1] Sadly, with time and periodic upheavals, both natural and human-caused, all but the treatise by Vitruvius himself have been lost. Consequently, his sole surviving book has carried extraordinary importance for Western architecture.

The basic elements of architectural design described by Vitruvius have remained essentially unchanged since the time that humans first began to shape their environment. Architecture, Vitruvius wrote, must provide utility, firmness, and beauty or, as Sir Henry Wotten later paraphrased it in the seventeenth century, commodity, firmness, and delight. By utility, Vitruvius meant the functional arrangement of rooms and spaces so that there is no hindrance to use and so that a building is perfectly adjusted to its site. Firmness referred to foundations that were solid and to building materials being used wisely to do their required work. Beauty meant that "the appearance of the work is pleasing and in good taste, and [that] its members are in due proportion according to correct principles of symmetry."[2] No matter how this notion of beauty, or *venustas,* may have been construed in the intervening centuries, the Vitruvian triad still remains a valid primary summary of the elements of good architecture. The ultimate tests of architecture are these: First, does a building work by supporting and reinforcing its functional use; does it enhance its setting? Second, is it built well enough to stand up; will its materials weather well? But third and equally important, does the building appeal to the visual senses; does it provide a full measure of satisfaction *and* enjoyment—does it provide delight?

In the creation of architecture, there is another fundamental triad, however, that Vitruvius does not discuss directly. First is the person or group who calls the building into being, the ***client*** who provides the commission. The client is the source of funding—and of all the arts (except the performance of large-scale musical and dance works, and making motion pictures), architectural building is the most expensive to produce. And in terms of all aspects of building, it is the client who ultimately calls the shots. Second is the ***architect*** or designer who gives the client's wishes physical form, whether on clay tablets, papyrus, parchment, or paper or in bits of binary memory. To this should be added the assistant architects, the scores of drafts-people, cost estimators, materials specialists, and many other employees in a large architectural office. Third is the even larger army of ***builders*** who carry out the construction process following the architect's instructions: those who excavate and build the foundations, fabricate the structural frame and walls, apply the external and internal surface finishes, install the complex plumbing and mechanical systems (which today can easily account for half the cost of a building), and construct the furnishing called for by the architect. Architecture, in contrast to all the other durable arts, requires the services and contributions of many hundreds of participants, especially in large structures. Because of this commitment of energies and resources, building is no trivial or impulsive endeavor; it is a "bottom-line" activity, involving the expenditure of significant amounts of money. William A. Starrett, the general contractor of the Empire State Building, wrote in 1928 that "building skyscrapers is the nearest peace-time equivalent of war," so complex are the intertwined logistics of such construction. Architecture is arguably the most accurate, the most truly revealing, human cultural artifact.[3]

Function

The Vitruvian three-part definition of architecture, incorporating utility, firmness, and beauty, begins with the element that, on the surface, would appear most straightforward but that, since the mid-twentieth century, has proved extremely complex and multifaceted. This element is ***function***. Function, or the pragmatic utility of an object—its being fitted to a particular use—was a criterion analyzed by such Greek philosophers as Plato, Aristotle, and Xenophon.[4] Part of the difficulty we face is that there is only one word in English for function, whereas we need variations to describe different kinds of function. Our alternative has been to make compound words such as *circulatory function* or *acoustical function.*

Making the problem worse, in about 1920 the definition of function became restricted to a narrowly utilitarian or mechanical sense with the rise of what became called International Modern architecture—the "International Style," as it was christened in 1932 by Henry-Russell Hitchcock and Philip Johnson. Two models of this type of building are the AEG turbine factory, Berlin, 1908–1909, by Peter Behrens, and the Fagus factory, Alfeld, Germany, 1911, by Walter Gropius [2.1, 2.2]. In both of these buildings, the form was almost totally determined by a linear analysis of the internal industrial processes. In 1926, Gropius designed the new building for the Dessau (Germany) Bauhaus school, whose workshop wing exemplified the same industrial determinism [19.18]. At the same time, Gropius wrote of the new architecture: "A thing is determined by its nature and if it is to be fashioned so as to work properly, its essence must be investigated and fully grasped. A thing must answer its purpose in every way, that is fulfill its function in a practical sense, and must thus be serviceable, reliable, and cheap."[5] The Swiss-French architect Charles-Édouard Jeanneret (who wrote under the pen name Le Corbusier) described the functional inadequacy of the contemporary house, saying that, for the twentieth century and the new architecture demanded by it, "the house is a machine for living in."[6] The architect Bruno Taut summarized the intent of International Modern architecture in 1929: "The aim of architecture is the creation of the perfect, and therefore most beautiful, efficiency."[7] In short, beauty would result *automatically* from the expression of the leanest, strictest utility.

The problem that became increasingly manifest from the mid-twentieth century onward, however, was that few buildings (other than factories or other similar industrial structures) have the kind of internal process that can determine building form in such a direct, linear, and utilitarian way. Most human activities cannot be reduced to a kind of mechanical formula. And if the internal functional use is changed, does beauty shift? Stanley Abercrombie made an interesting observation regarding functional accommodation equating to beauty. He noted that Brunelleschi's Foundling Hospital in Florence, Italy, was essentially built by 1427 but was not completely finished until January 1445 and, further, that it was not put into operation for the care of orphans until February 5 [15.7]. When did it become beautiful—in 1427 or 1445, in January or February?[8] Furthermore, simply accommodating all the utilitarian functional requirements ignores much. The American architect Louis I. Kahn believed that "when you make a building, you make a life. It comes out of life, and you really make a life. It talks to you. When you have *only* the comprehension of the function of a building, it would not become an environment of a life."[9]

Another problem we have had to face in the last two centuries is that few buildings have continued to accommodate the function for which they were originally designed. This has necessitated enlargements, modifications, or the construction of wholly new buildings, with the original building being converted to a new use. The temptation would be to say that an old building was never functional because it cannot easily accommodate the *new* use we want it to serve. It may, in fact, have accommodated its original use very well.

An alternative is to design a building so that any possible future activity can be accommodated. This approach was taken in the mid-twentieth century

2.1. Peter Behrens, AEG Turbine Factory, Berlin, Germany, 1908. Behrens hoped in such factory buildings to create a more noble architecture, to raise the design of the factory to a higher aesthetic plane as a type to inspire all architecture. Photo: Foto Marburg/Art Resource, NY.

2.2. Walter Gropius and Adolf Meyer, Fagus Factory administrative wing, Alfeld-an-der-Leine, Germany, 1911–1912. Gropius followed the direction of his teacher Behrens in using an industrial expression for the administrative office wing of the factory. Photo: Vanni Archive/Art Resource, NY. © Artists Rights Society (ARS), New York/ VG Bild-Kunst, Bonn.

by Ludwig Mies van der Rohe, who devised what he called the *Vielzweckraum*, the "all-purpose space" or "universal space." Indeed, Mies said that he and his associates did not fit form to function: "We reverse this, and make a practical and satisfying shape, and then fit the functions into it. Today this is the only practical way to build, because the functions of most buildings are continually changing, but economically the building cannot change."[10] This multifunctional approach is demonstrated in the huge single room of Crown Hall, the school of architecture of the Illinois Institute of Technology, Chicago, 1952–1956 [2.3]. While such a vast single room can indeed hold any variety of future activities, it does not function at all well acoustically, for a sound generated in any part of the room ripples and reverberates through the entire space. Mies van der Rohe put into built form what a number of International Modernist architects had believed since the 1920s: that there was a universality of human needs and function. Le Corbusier even claimed it was possible to design "one single building for all nations and climates."[11] Unfortunately, this notion, so appealing in the mid-twentieth century because of its apparent simplicity, ignores the idea that function is socially and culturally determined and that a building's form is, in addition, a response to its psychological character, its physical setting, and the climate. As will be noted in Chapter 20, the impact of social convention and of regional and ethnic factors was rediscovered late in the twentieth century.

Function, therefore, has many components, the most basic of which is ***utilitarian*** or ***pragmatic utility***, or the accommodation of a specific use or activity in a specific room or space. A room might be used to contain a single bed for sleeping, it might be an office cell containing a desk, or it might be a large orchestral hall or some other public space.

Most buildings, of course, are composed of numerous rooms with interrelated functions. People therefore need to move from one room to another, so that almost as important as the utilitarian function is the ***circulatory function***, the making of appropriate spaces to accommodate, direct, and facilitate movement from area to area. When Charles Garnier designed the Paris Opéra, 1861–1875, he

2.3. Ludwig Mies van der Rohe, Crown Hall, Illinois Institute of Technology, Chicago, Illinois, 1952–1956. The interior consists of one vast room designed to house a variety of differing utilitarian functions. Photo: Rosenthal Collection, Department of Art History, Northwestern University.

2.4. Charles Garnier, Paris Opéra, Paris, France, 1861–1875. Stair Hall. For the Paris Opéra, social interaction, observing and greeting one another in the circulation spaces, was perhaps the primary function. Painting in the Musée Carnavalet, Paris; photo: Scala/Art Resource, NY.

analyzed just what the true function of the opera was. Certainly, he realized, Parisians went to hear the latest opera, but as Garnier also correctly understood, there was perhaps an even more important social reason for going to the opera—people went there to see and be seen. Its social function was as important as, or even more important than, its musical function. In fact, Garnier spent time at existing facilities around Paris examining how people moved, the numbers of people strolling in small groups, and how much distance the groups maintained between themselves as they moved about. These became his modules of measurement in designing the new Opéra. Further, as he quickly realized, the circulatory areas were every bit as important as the stage house and the auditorium, and as his plan clearly reveals, the grand stair, the foyer, and the vestibules make up a significant portion of the total floor area [2.4, Plate 2].

Similarly, when, toward the end of the nineteenth century, Louis Sullivan set out to design some of the first metal-framed commercial skyscrapers, he first examined just what this new type of building enclosed.[12] He discovered that there were five distinct utilitarian zones. The bottom-most was the basement, which contained machinery, storage, and other strictly utilitarian uses [2.5, p. 20]. Above that were four distinctly different functional uses: (1) the ground floor (containing the entrances, the elevator lobby, and shops at the perimeter facing the street); (2) a mezzanine level that might house support rooms for the shops below or offices opening onto an internal court; (3) the central section (floor upon floor of identical office cells arranged around the elevator); and (4) the terminating upper floor or floors (with elevator machinery, water tanks, storage, and other miscellaneous uses). For simplicity's sake, Sullivan himself often described this as being like a Classical column with a base, a mid-section shaft, and a capital or top. Since the new, tall office block was decidedly vertical in form, Sullivan argued that it was the architect's responsibility to emphasize this verticality and to express clearly the three functional zones, as he did in the Wainwright office building, Saint Louis, Missouri, 1890–1891.

Another architect who exploited the potential for expressive form by celebrating different functional activities was the Finnish architect Alvar Aalto. Among his best examples is one of the two buildings he designed in the United States: the library for the Benedictine monastery at St. Benedict near Mount Angel, Oregon, 1967–1971 [2.6]. Its principal pragmatic function is simply to contain books, which are arranged in bookcases that fan out northward from the central reading and circulation core. But its other support activities require different spaces, so on the north side are closely fitted rectangular offices and workrooms for the staff and to the south is a wedge-shaped auditorium. Each of the spaces is placed where it needs to be, is shaped in the best way to accommodate its use, and joins with the other spaces to form a harmonious whole.

A building often also has a symbolic function and makes a visible statement about its use. We usually expect some correspondence between what the building's use *appears to be* and what the use *actually is.* From the time of the Egyptians, Greeks, and Romans, up through Renaissance and Baroque architecture (that is, until about 1750), there were general guidelines regarding the form and appearance of buildings for ceremonial uses, but now there is much greater latitude. Since roughly 1920, therefore, architects have had to do two things simulta-

2.6. Alvar Aalto, Mount Angel Abbey Library, Mount Angel, Oregon, 1967–1971. The plan arrangement illustrates the differing functional activities: public entry, staff work areas, the auditorium, and reading/book storage. Drawing: L. M. Roth.

2.7. Mies van der Rohe, Boiler House, Illinois Institute of Technology, Chicago, Illinois, 1940. Heating plant building. With its tower-like chimney and high clerestory windows, this building has the physical attributes of early churches. Photo by Hedrich Blessing. Chicago History Museum, negative HB-12979B.

neously: invent original forms using new building technologies and, *at the same time,* devise appropriate new symbolic representations for the functions that their structures are housing. Often, the exploitation of new technologies has taken precedence over symbolic representation, and many mid-twentieth-century buildings truly tell us almost nothing about what goes on inside them. As an example, compare two buildings designed by Mies van der Rohe for the campus of the Illinois Institute of Technology (IIT) during 1940–1950 [2.7, 19.39]. One is the boiler house, perhaps the most utilitarian building of the ensemble; the other is the chapel. Yet nothing in either the form or the material of the chapel tells us how its function differs from that of the boiler house. In fact, using Early Christian buildings as prototypes, since one of the IIT buildings has high clerestory windows with a tower set to the side, we might mistakenly take the power plant for a church. Perhaps Mies van der Rohe was viewing the chapel as an all-purpose space and shunned the creation of a fixed image, allowing a new use to be accommodated later (in fact, by 1998, the IIT chapel had been converted to storage space). One might contrast the all-purpose IIT chapel with the interior of the Zion Lutheran Church, Portland, Oregon, 1950, by Pietro Belluschi [2.8], which to most observers suggests the character of a church without attempting to literally re-create Gothic vaults, crockets, or finials.

In the United States, the national Capitol Building in Washington established an image of governmental architecture, and since 1800, that image was recalled many times in successive new state capitols. One example is the Minnesota State Capitol, Saint Paul, 1895–1905, by Cass Gilbert [2.9]. Like the national capitol, this has two chambers on either side of a central circulation chamber that is capped by a tall dome. The Minnesota dome is specifically patterned after that of the Basilica of

2.8. Pietro Belluschi, Zion Lutheran Church, Portland, Oregon, 1950. Through the simple use of colored glass and laminated arches in wood, the traditional image of a church is suggested. Photo: © Wayne Andrews/Esto. All rights reserved.

Saint Peter in Rome, but the image conveyed is of a building in which the legislature does its business; the high dome of glistening white marble proclaims that function across the landscape of Saint Paul. In another more abstract example, when Eero Saarinen was engaged in 1956 to design a terminal building for Trans World Airlines at Idlewild (now Kennedy) Airport, New York, he set out to shape a building that, in architectural terms alone, would convey symbolically the mystery and magic of flight [2.10]. He and his associates conceived a building with great concrete shells cantilevering out from the center like giant wings, and interior surfaces that sweep, curve, and rise without sharp angles or corners. The fluid, sculptural architectural form psychologically prepared travelers for the miracle of flight as they passed through to board a plane.

Seldom is a building devoted wholly to one kind of function. Most buildings contain a mixture of purely utilitarian function and symbolic function. For any given building type, the mix of utilitarian and symbolic elements shifts over time. In the mid-twentieth century, a public library or a city hall might have been more purely utilitarian, but by the end of the twentieth century, just as in the nineteenth century, these buildings favored symbolic function much more. With the general spread of the various Postmodernism alternatives at the end of the twentieth century, such buildings have been given a greater component of symbolic functional expression.

Architecture also has important psychological and physiological functions to fulfill. For example, a hospital emergency waiting room is a place where most people experience great apprehension and distress. The architect might determine that creating a restful, domestic atmosphere like that of a home living room—perhaps with a view out to an enclosed garden, rather than an antiseptic, clinical space—would help reduce those anxieties. To mention just one example among many, the Riverbend Sacred Heart Medical Center in Eugene-Springfield,

2.9. Cass Gilbert, Minnesota State Capitol, Saint Paul, Minnesota, 1895–1905. Based on the Capitol in Washington, DC, this building clearly evokes the image of an American government building. Photo: L. M. Roth.

2.10. Eero Saarinen, Trans World Airlines Terminal, John F. Kennedy Airport, New York, NY, 1956–1962. With its soaring cantilevered concrete wings, Saarinen endeavored to shape in the TWA Terminal a symbolic representation of the magic of flight. Photo: L. M. Roth.

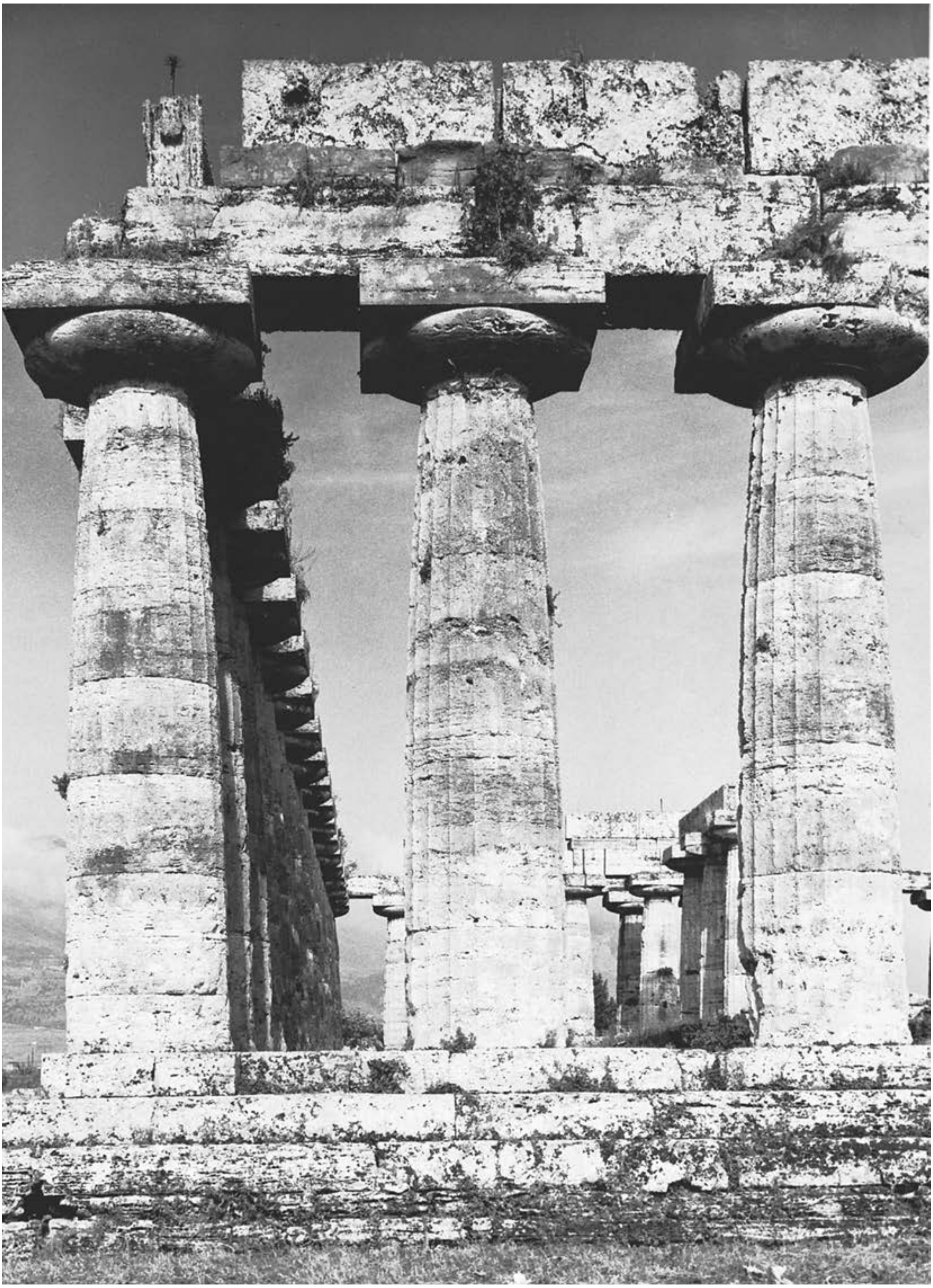
Oregon, 2002–2008, by Todd Tierney and Bill Lee of Anshen + Allen Architects, was conceived from the outset as a place not just for physical healing but for mental healing as well. Accordingly, the site selected is adjacent to the McKenzie River in a mature grove of towering Douglas firs, allowing for a paved path to weave among the trees where family members can stroll and reconnect with the natural environment. The exterior of red brick with massive wood beams and trusses opens to a two-story visitors' entry lobby with wood paneling and a stone fireplace that suggests more the lobby of a ski lodge than that of a sterile clinic. Small lounges on the upper floors, strategically located near intensive care and cancer wards, have broad windows that open onto roof gardens arnd use rain water to form “green roofs” [2.11]. In each patient's room is a built-in window seat/daybed so that, for example, a parent can sleep overnight to comfort an ill child. Clearly, in the design of this building, the needs of distressed family members were as carefully considered as those of the injured and seriously ill patients.

Besides what was achieved in this hospital there is a special psychological function that we might define as the optimum satisfaction of all the types of function just described. One modern architect who strikingly achieved psychological function on an abstract level was the American architect Louis I. Kahn, whose work is represented in the Jonas Salk Institute for Biological Studies, La Jolla, California, 1959–1965 [19.55]. Just as Garnier did for the Paris Opéra, Kahn penetratingly analyzed what the range of functions was to be in the laboratory, and he saw that satisfying the purely utilitarian and highly specialized function of providing space for conducting experiments was only part of his task. He was fortunate, too, that his client, the scientist Jonas Salk, likewise perceived the need for something more than the utilitarian. As Kahn said, Salk recognized that “the scientist . . . needed more than anything the presence of the unmeasurable, which is the realm of the artist.”[13] Accordingly, the laboratory spaces were separated into two parts: large antiseptic spaces for work and small, private humane spaces for reflection. The large, universal spaces for setting up the experiments are on the outside of the U-shaped plan, while budding from their inward faces are the private studies. The work

2.11. Todd Tierney and Bill Lee, with landscape architect. RiverBend Sacred Heart Medical Center, Eugene-Springfield, Oregon, 2002–2008. In various internal locations, and on various rooftops, where the most at-risk patients would be located, healing gardens are provided either as visible respite or as quiet places to withdraw, places to promote spiritual and psychological healing. Photo: L. M. Roth, 2013.

spaces are expansive and functionally efficient, whereas the studies are small, intimate, and private, paneled in teak, with windows angled so that the researchers look out westward toward the open expanse of the Pacific Ocean. The work spaces are focused on empirical research; the private studies are designed to encourage a community of minds and private contemplation of the meaning of the research at hand. As Kahn and Salk wished to make clear, science is more than simply the raw accumulation of data. Although medical science grows out of the inextinguishable human desire to know, such knowledge inevitably influences the quality of human life and hence calls for the most penetrating, sober reflection.

Architecture is more than functional utility or structural display—it is the vessel that silently, perpetually, and inescapably shapes human life.



3.1. Temple of Poseidon, Paestum, Italy, c. 550 BCE. This stone column, larger than structurally necessary, conveys a clear impression of its strength. Photo: G. E. Kidder-Smith.

"Firmeness"

Structure, or How Does the Building Stand Up?

Architecture . . . is the crystallization of its inner structure, the slow unfolding of form. That is the reason why technology and architecture are so closely related.

—Ludwig Mies van der Rohe, speech to Illinois Institute of Technology students, 1950

The most apparent part of a building is its structure, or what makes it stand up. This has been more obvious since the mid-twentieth century, when architects and engineers took particular delight in making structures do more work with less material, seemingly in defiance of gravity, while showing the structure more clearly. The tension we may feel when looking at a modern structure so delicate as to seem in danger of imminent collapse illustrates the difference between the ***physical structure***, that is, the "bones" of the building that do the work, and the ***perceptual structure***, or what we see. They are not the same, for a column may be much larger than structurally necessary in an engineering sense simply to reassure us that it is indeed big enough for its job. Such is the case with the extraordinarily thick columns of the Temple of Poseidon at Paestum, Italy [3.1, p. 32].

In a comparison between Lever House, New York, by Skidmore, Owings and Merrill, 1951–1952 [3.2], and the neighboring New York Racquet and Tennis Club, by the office of McKim, Mead & White, 1916–1919, we see a contrast between a wall of glass that hides the structure and a traditional massive masonry wall. The wall of the Racquet and Tennis Club looks stronger than it needs to be and reassures us through its structural excess, whereas the actual physical columns of Lever House are covered by a suspended skin of green glass, and there is no readily perceptible clue as to what holds the building up. Since we sense from experience that sheets of glass by themselves cannot hold up a building of that size, we must therefore visually hunt for the actual structure (the architects force us into a kind of game) until we finally see the columns emerge at the base of the building. This play between what we know to be a heavy building and its apparent weightlessness is part of the visual tease of these glass-skinned skyscrapers. Some modern viewers take delight in the idea that gravity has been cheated (although observers of earlier periods might have considered the structure of the building poorly expressed).

The emphasis in the preceding paragraphs on visible structure ignores perhaps the most important structural element in a building, the nonvisible portion—how it is supported on the ground itself (that is, on its foundation). There is a balancing act between the weight of the finished building and what the soil beneath it can bear. In mid-town New York City it is typically the case that the Manhattan Schist bedrock is just below the surface (and above the surface in parts of Central Park), so that excavating a basement means drilling and blasting the bedrock to create a hole. Buildings erected directly on this bedrock sit solidly and immovably. In Chicago the conditions below the sidewalk level are altogether different. During the Ice Ages the glaciers that repeatedly pushed through this area left behind layer upon layer of material—soft clay, hard-packed clay, gravel, sand—multiple layers in no particular order. Solid Joliet Limestone bedrock can lie anywhere from 100 to 200 feet below the many layers of softer materials [3.3]. The earliest commercial buildings built there in the 1850s through the 1870s had spread footings below their supporting masonry walls, but as the buildings got taller and taller in the 1880s, problems began to emerge in connection with uneven settling of the larger, heavier buildings. By the 1880s, Chicago architects and engineers had

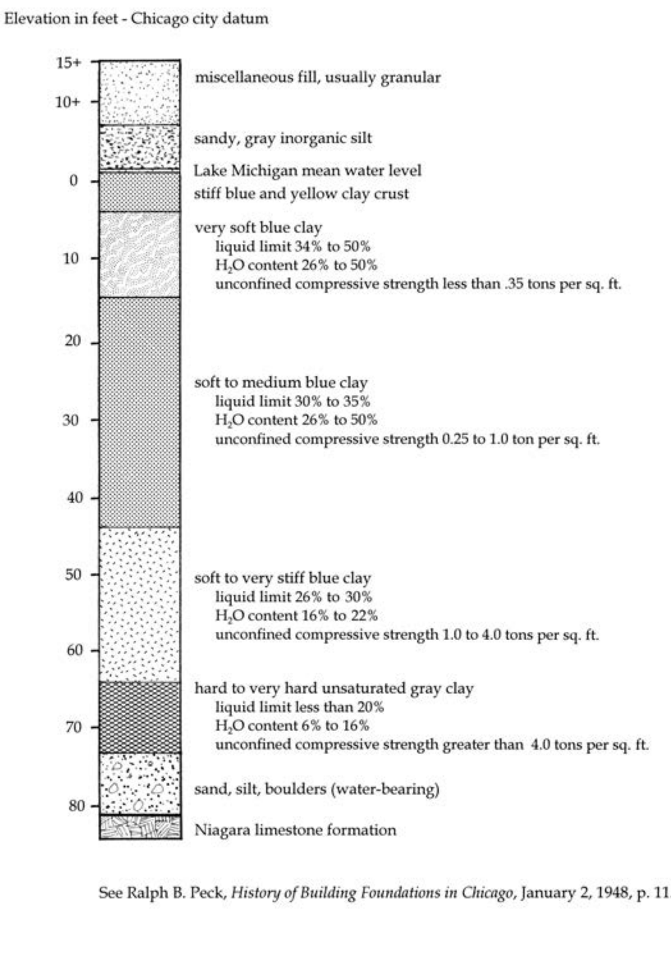
3.2. Skidmore, Owings & Merrill, Lever House, New York, 1951–1952. With its glass envelope suspended from the inner skeleton, Lever House visually hides its structure, whereas the adjacent New York Racquet and Tennis Club (by McKim, Mead & White, 1916–1919) has a boldly expressed wall structure. Photo: L. M. Roth.

developed ways of measuring the bearing capacity of the soil underneath the various parts of a projected building and then proportioning the size of each footing pad under a wall or column to match the bearing capacity at that point; the buildings settled into the soft soil as anticipated, but they did so evenly. Architects who did not adopt this practice started to notice that parts of their buildings, particularly high towers, began to settle more and cause cracks to open up in their just-finished buildings.

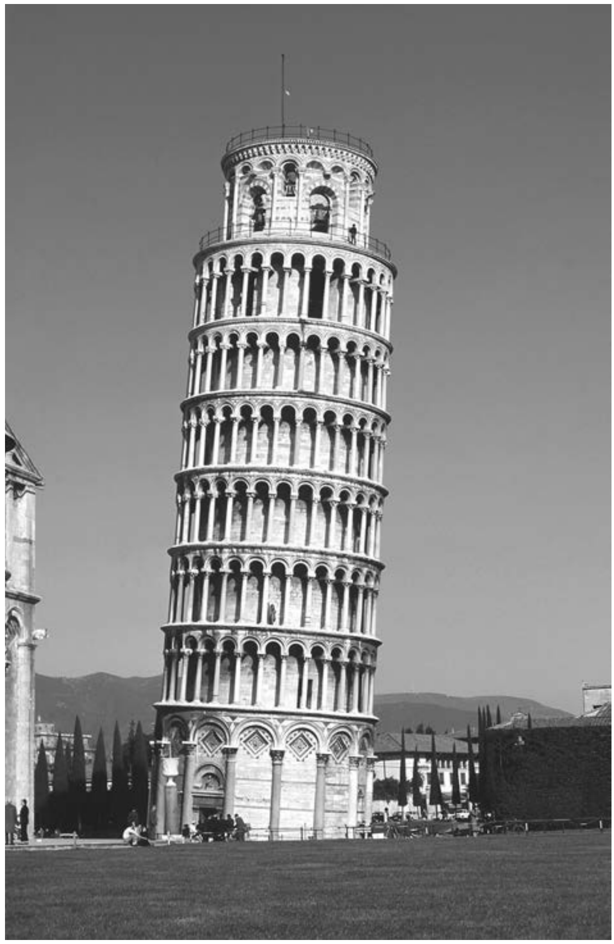
The same foundation problems seen in Chicago had been observed centuries earlier in the city of Pisa, Tuscany, Italy, in the twelfth century [3.4]. Begun in 1173, when the foundations for the freestanding bell tower were laid, the tower soon began to lean to the side when construction had reached only the second-floor level in 1178. Foundations only 9 feet deep rested on soil that had less bearing capacity on one side. Construction was stopped (since, in any case, Pisa was involved in political and military contests with surrounding cities) but resumed in 1272 when the architect at that time decided to build the new floors with one side higher than the other, making the tower look straighter but giving it a curve. The final seventh floor was built in 1319, continuing this countercurve. The tower continued its slow leaning, year after year. In 1964 the Italian government requested aid from engineers worldwide to prevent the tower from toppling (though there was no thought of trying to undo the sideways lean altogether, due to its appeal for tourism). Considerable study was focused on the problem, and the tower closed to the public while it was stabilized with cables attached to anchors several hundred meters away. The solution involved the removal of around 100 cubic meters of soil under the higher side of the tower base, allowing it to slowly lean back and straighten up slightly—pulling back roughly 45 cm (15 in) to re-achieve its angle as of 1838. In 2008, engineers declared that, due to the remedial measures taken, the tower had stopped its slow leaning motion for the first time in its history; it is now open to the public once again.

Through our childhood play we grow up developing a good intuitive sense of gravity and how it affects objects around us, for from the first moment we try to move our limbs (once removed from the comparative weightless state of the womb), we experience the unceasing pull of gravity. As infants, we must figure out how to raise our bodies erect and maintain a state of equilibrium, or stasis, while standing, and then how to move on two legs. Accordingly, long before we can articulate the concept in scientific terms, as infants we have a clear idea that objects that are not supported will fall straight down, or, to be exact, toward the center of the earth. And that is the essence of architectural structure—making sure that objects will not fall to the earth, despite the incessant pull of gravity.

We develop early a way of understanding objects around us through ***empathy***, of imagining ourselves inside the object and feeling how gravity works on it. So, for example, when we see the pyramids in Egypt, we sense that they are inherently stable objects, whereas when we see something like the inverted pyramid of Shapero Hall of Pharmacy at Wayne State University, Detroit [3.5], we feel a sense of instability and perhaps marvel at the work of the architect and the engineer who placed such a structure on its head. In the case of Lever House, the architect played with our differing perceptions of solid stone and transparent glass, knowing that we would sense one building (the Racquet and Tennis Club) as solid and heavy, and Lever House as



3.3. Diagram illustrating varying subsoil conditions in Chicago. Because of repeated glacial scrapping and deposit of differing soils over many millennia, the subsoil of Chicago is made up of numerous layers of sand, gravel, and clay, all varying in bearing capacity. Drawing: L. M. Roth.



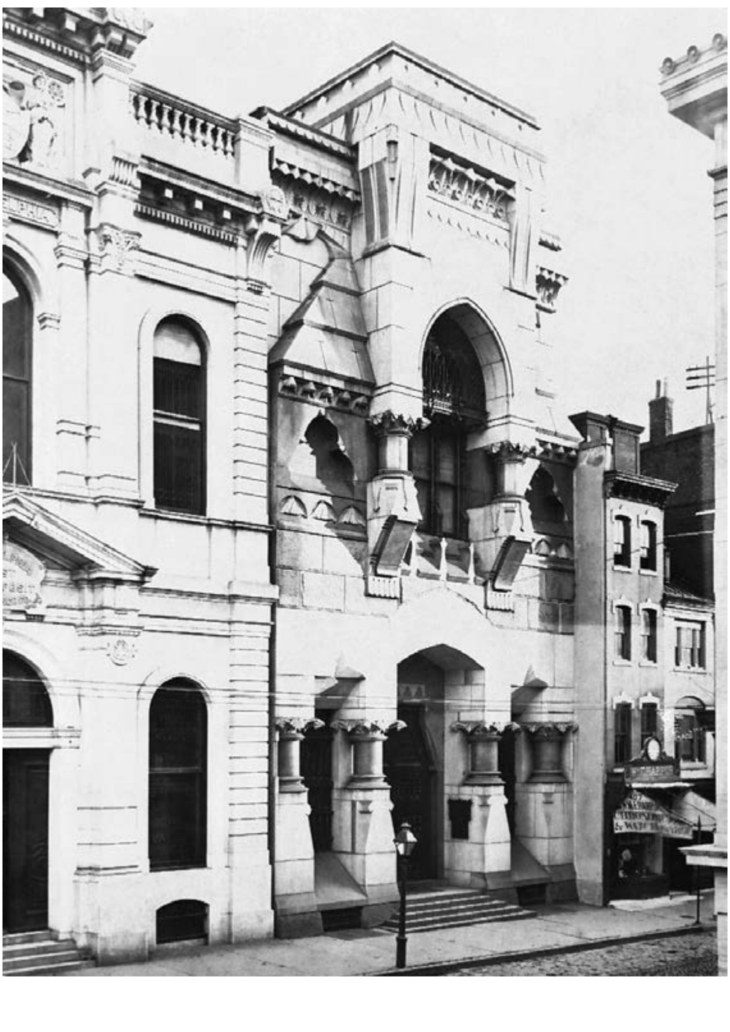
3.4. Guglielmo, Giovanni di Simone, and Tommaso di Andrea Pisano, Campanile Tower of Pisa, 1173–1350. The alluvial soil beneath Pisa is made up of varying layers, with the bearing capacity per square inch on one side of the tower being less than on the other side, resulting in the tower's settling more into the softer side. Photo: Art Resource, NY.

light. Some architects, in fact, have taken pains to accentuate the sense of weight, as did Frank Furness, a nineteenth-century architect from Philadelphia. His Provident Life and Trust Company, Philadelphia, 1876–1879 [3.6], a building regrettably now demolished, projected a sense of immense weight, so that the parts of the building seemed to be compressed, sliding downward and telescoping into one another under the pull of gravity.

Part of our perception of architecture has to do with this empathetic analysis of how forces are handled in buildings. Hence, what we perceive at Paestum and in the Parthenon in Athens [11.28] is a careful balance of vertical and horizontal elements, neither of which dominates, suggesting a delicate equilibrium of forces and thus exemplifying the classical Greek philosophical ideal. In contrast, Gothic architecture, as represented by the east end of the cathedral of Beauvais, France, is characterized by soaring, thin, vertical supports and a multiplicity of vertical lines [3.7]. All of this suggests ascent, lift, weightlessness, aspiration, and a visual denial of the tremendous forces being generated by the roof and inner stone vaults 140 feet (42.7 m) in the air, both vertically and laterally or spreading outward, all insistent on being conducted safely down to the ground and to the invisible foundations below.

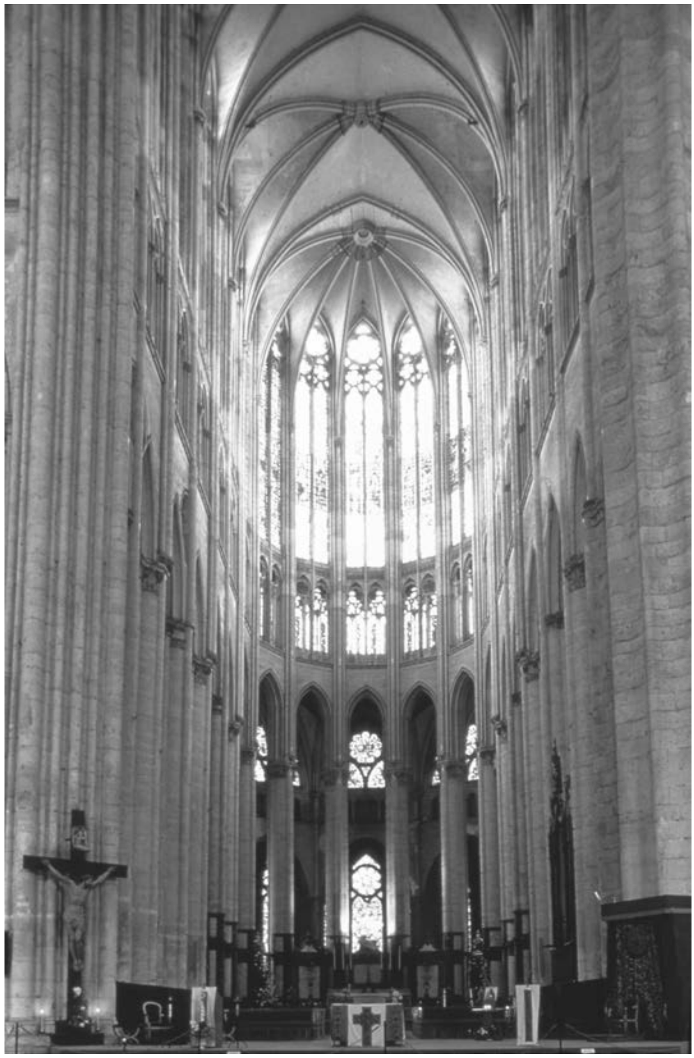
Elements of the Oldest Architecture

We will likely never be certain just when humans began to fabricate structures to protect themselves, because once out from under the shelter of the primeval cave, the earliest structures humans put together used tree saplings, thatch, grass, animal skins, and other organic materials that all quickly returned to the earth. Most such shelters probably lasted no more than 10 or 20 years. In at least one instance (discovered so far), such organic dwelling



3.5. Paulsen and Gardner, Shapero Hall of Pharmacy, Wayne State University, Detroit, Michigan, 1965. This unusual building, seeming to rest on its smallest point, makes the viewer wonder how it is held up. Photo: University Archives, Wayne State University.

3.6. Frank Furness, Provident Life and Trust Company, Philadelphia, Pennsylvania, 1876–1879 (demolished 1959). The architect deliberately exploited strong contrasts in form, scale, and texture to create an image that was bold and unique. Photo: Penrose Collection, Historical Society of Pennsylvania.



3.7. Choir of Saint-Pierre Beauvais, France 1225–1569. In this building, devoted to the aspiration to heaven, the vertical line dominates everywhere. Photo: Anthony Scibilia/ Art Resource, NY.

building materials did survive for more than 13,000 years, to be uncovered in the 1970s. These were the wood timbers and hides of shelters found at a site called Monte Verde, Chile, discussed in Chapter 9 [9.4, p. 171]. Far older, however, are the indications of branches being used to enclose a shelter some 400,000 years ago, at a location called Terra Amata off the Mediterranean coast of southern France. The branches themselves long ago disappeared, though their indentations remained in the ancient soil when it was uncovered in the 1960s.

When European settlers first arrived on the Atlantic coast, dwellings similar in construction to those found at Monte Verde, Chile, were being lived in by the Powhatan and Wampanogue Native Americans (to name just the tribes encountered by the first English settlers in Virginia and New England). Rounded wigwams, and also somewhat elongated rectangular round-topped houses, were built of saplings pushed into the ground and bent over in a series of parallel U-shaped hoops, the frame then being covered with sheets of elm or birch bark, layers of sewn reed mats, or animal skins [3.8]. In analogous ways—also exploiting local materials such as thin saplings, wood lattice covered with adobe (wattle and daub), palm, grass thatch, or even adobe bricks—various African tribes continue to use ancestral building techniques to construct dwellings.

Another ancient building material is adobe, used to great advantage around the world where earth

3.8. Algonquian longhouse and wigwam dwelling types. An Algonquin Indian village traditionally was made of bark-covered dwellings such as wigwams and longhouses in the Northeast woodlands. Photo: Copyright Marilyn Angel Wynn. Courtesy of The Institute for American Indian Studies, Washington, CT.

with a clay content can be mixed with water (with perhaps an admixture of grass or straw to serve as an additional binder) to form building blocks or bricks. Typically these building units are dried and "baked" in the sun. Adobe's density and mass make it a good thermal insulator (or heat storage mass); these aspects of adobe are discussed in Chapter 6. Adobe is highly serviceable in dry desert-like environments where rain is light and infrequent. So long as a sacrificial outer coat of adobe plaster is continually maintained through periodic replastering, the protective plaster keeps the inner structural adobe building blocks from dissolving. That this easily crumbled and rain-vulnerable material can be used for long-term durable buildings is illustrated well by the Taos Pueblo structures built in northern New Mexico during 1000 to 1450 CE (and replastered every autumn) [3.9], as well as the Great Mosque at Djenné, Mali, Africa, built initially in the thirteenth century and rebuilt in 1906–1907. The projecting bundles of rodier palm provide scaffolding for annual maintenance [AF-4, p. 552].

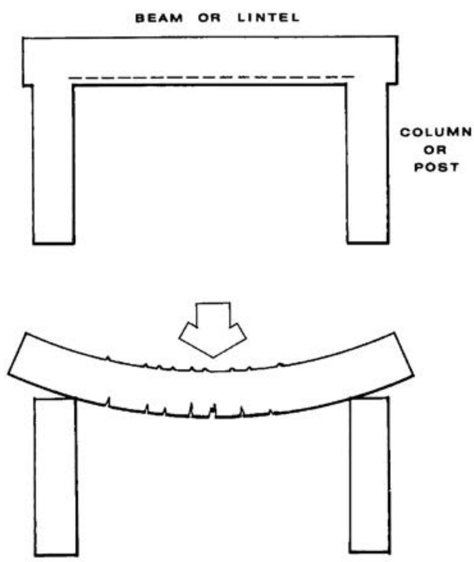
The Elements of Lithic (Stone) Structure: The Post and Lintel

The beginning of a more durable structure is the stone wall, but a room enclosed with walls has no light or view, so the wall must be opened up. The blocks or bricks over that opening must be supported against the pull of gravity, and this is done either by means of a beam (of wood or, after 1750, metal) or by means of an arch. Such a beam inserted in a wall to support the wall above is called a ***lintel***. The wall could also be cut away, so to speak, and replaced with slender stacks of blocks to form piers, or rounded shafts forming columns, with lintels spanning the spaces between them. The architect Louis Kahn spoke of "the momentous event when the wall parted and the column became."[1] The column and beam—or post and lintel—system is as old as human construction [3.10]. Archaeological and anthropological evidence suggests that post and lintel systems of wood or bound papyrus reeds were used long before they were translated into more

3.9. *Taos Pueblo, Taos, New Mexico, c. 1450. Photo: © Wayne Andrews/Esto. All rights reserved.*

durable stone. Such a post and beam system is called a ***trabeated*** system (from the Latin *trabs,* "beam"). One of the most straightforward examples of post and lintel construction is the Valley Temple east of the pyramid of Khafre, in Giza, Egypt, built between 2570 BCE and 2500 BCE [3.11]. Here, finely polished square lintel beams of red granite rest on square piers of the same material, contrasting with the alabaster floor. All beams, whether of stone, wood, or any other material, are acted on by gravity. Since all materials are flexible to varying degrees, beams tend to sag or deflect in the middle of their span as a result of their own weight, and even more as loads are applied. This means that the upper part of a beam between two supports is squeezed together and is in compression along the top surface, while the lower part is stretched and is said to be in tension.

Extending the beam over the end of the column results in a ***cantilever*** [3.12]. In a cantilever, the situation is exactly reversed over the supporting post, for as the extended projecting beam sags due to the pull of gravity, the *upper* part is stretched

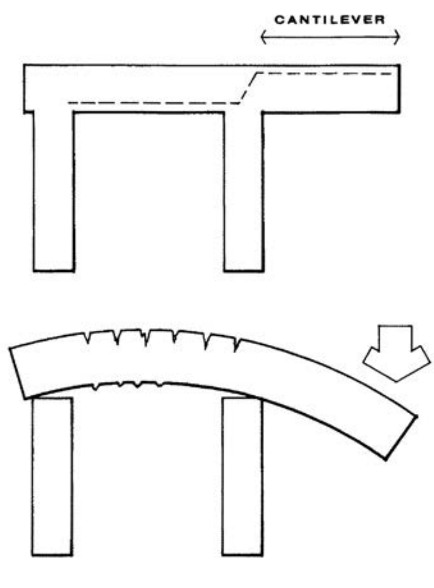


3.10. *Diagram of the post and lintel system. Drawing: L. M. Roth.*

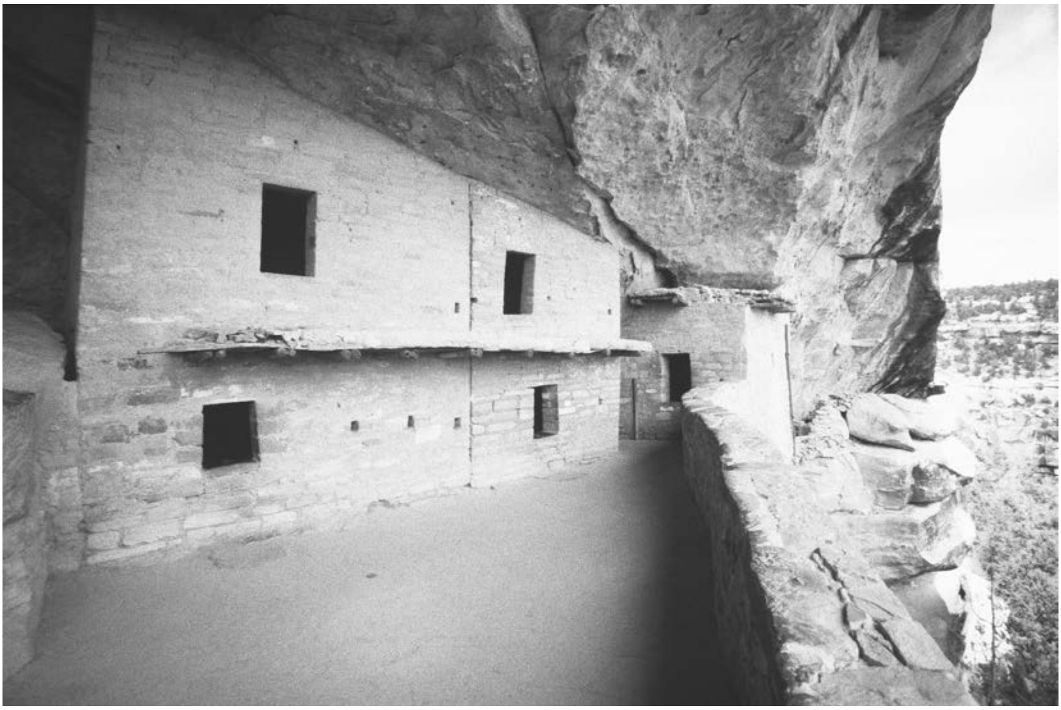
3.11. Valley Temple, Pyramid of Khafre, Giza, Egypt, c. 2570–2500 BCE. This is one of the purest and most direct expressions of stone post and lintel construction. Photo: Hirmer Verlag, Munich.

(put in tension) and the *lower* portion experiences squeezing compressive stresses. In the cantilever, these forces are strongest just over the support. In fact, it is the continuity of the material of the beam over the support that makes the cantilever possible. The perception of weightlessness that the cantilever suggests (together with the strong emphasis on the horizontal line) were characteristics greatly favored by Frank Lloyd Wright, perhaps nowhere more so than in the dramatic cantilevers he incorporated in his famous weekend house for Edgar Kaufmann called Fallingwater [4.24].

Wood, being a fibrous material, resists tensile stresses relatively well, as do wrought iron and rolled modern steel; beams of steel can span significant distances. The tensile forces along the bottom of a beam (or along the top of a cantilever) are determined by the length of the span and the load placed on the beam, so that eventually, given a sufficiently great span and high load, the tensile strength of the material will be exceeded; the beam will crack at the bottom (or along the top in a cantilever) and will eventually collapse. Stone and solid plain concrete have far less tensile strength than do fibrous wood or metal, so that a wooden beam over a given span might carry a load that would crack a stone beam [3.13]. Of course, the stone beam starts out being far heavier by itself, creating a significant load from the outset. In beams of concrete, which has great strength in areas of compression, the solution is to place something within the concrete that will take or resist the tensile forces. The solution to this problem, used by early Romans and modern-day builders alike, is to place iron (and now steel) rods in the formwork into which the liquid concrete is then poured. The result is reinforced concrete. As the dotted lines in 3.10 and 3.12 indicate, the steel is placed where the tensile forces accumulate—on the bottoms of concrete beams and at the top of concrete cantilevers.



3.12. Diagram of a cantilever. Drawing: L. M. Roth.



3.13. Balcony House, Mesa Verde, Colorado, c. 1250–1280. Photo: L. M. Roth.

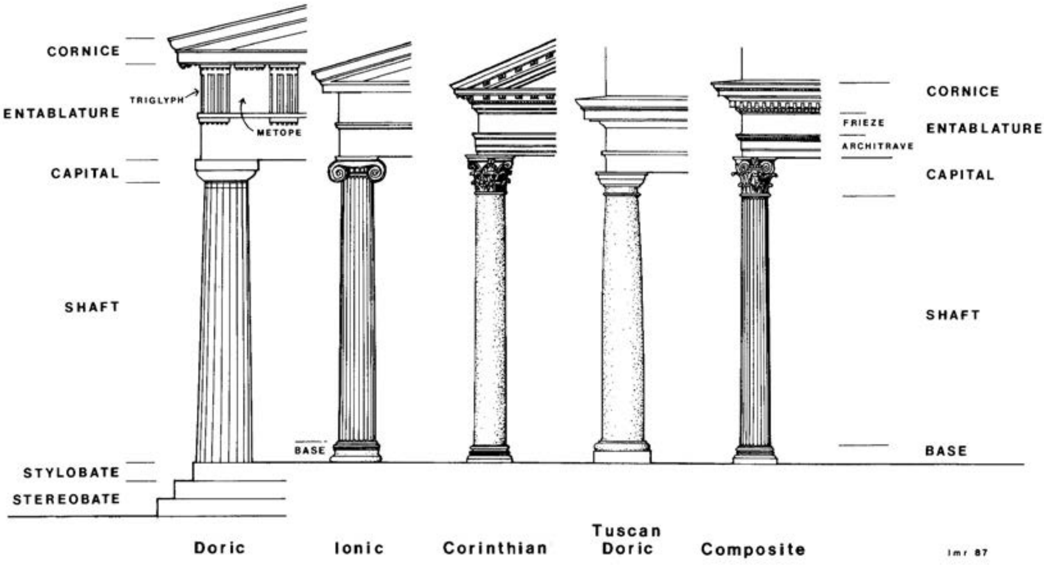
The ancient Greeks also faced this problem. The central opening of the gateway to the Akropolis in Athens, the Propylaia, built in 437–432 BCE [11.21], had to accommodate the passage of pairs of sacrificial oxen with their handlers. The gateway had to have a broad span of 18 feet (5.5 m), far too great for a solid block of marble that also had to carry the roof load. The solution adopted by the architect Mnesikles was to hollow out the beam to reduce its own weight (it still weighed eleven tons) and to place iron bars along the top of the beam, apparently to carry the weight of the marble blocks above. In this unique instance, the iron bars are at the top of the beam, not the bottom, where they would be expected today. Even so, over the centuries, cracks developed in the marble lintel beam.

The Classical Orders

The columns of the Propylaia are splendid examples of one of the three column types the Greeks developed for their civic and religious architecture: Doric, Ionic, and Corinthian [3.14]. These three columnar types, or orders, were adapted by the Romans, who added more ornate variations of their own (Tuscan and Composite), and the orders later became part of the basic architectural vocabulary from the Renaissance in the fifteenth century down to our own times. The columns of each Greek order consist of three basic parts—base, shaft, and capital—and, in Greek usage, rise from the three-stepped temple base composed of the top ***stylobate*** (from the Greek *stulos,* "column," plus *bates*, "base"), with a two-step ***stereobate*** below. In all the Greek orders, the height of the column and the relative size of all the related component parts, as well as of the ***entablature***, are proportional derivatives based on the diameter of the column.

Aside from each of the orders rising from some sort of base platform, each carries a stylized beam and cross-beam ends, all capped with a cornice. This assembly of beams atop the column is called the *entablature* and consists of three basic layers, varying slightly between the different orders. The entablature of the Doric order is made up of (1) the lower ***architrave*** (from *arch,* "main," plus *trabs,* "beam"), (2) the middle range made up of alternated ***triglyphs*** (stylized beam ends) and ***metopes*** (sculpted infill panels), and (3) the uppermost ***cornice***, formed of several progressively projecting moldings.

Doric columns [3.15], the most massive of the three Greek orders, are four to six and a half times as tall as the diameter, and the Doric *entablature* (the stylized system of beams and beam ends resting

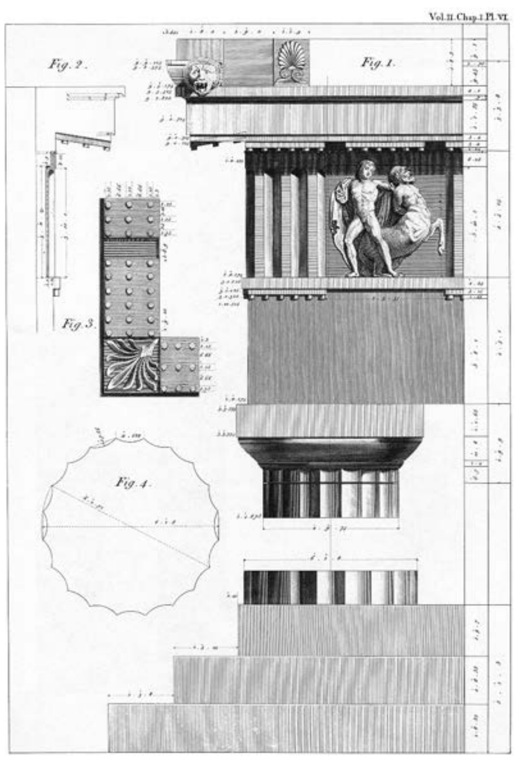


3.14. Comparison of the five Classical orders. The Greek orders consisted of the Doric, Ionic, and Corinthian. To these the Romans added the Composite (a combination of the Ionic and Corinthian) and the simpler and thicker Tuscan Doric. Drawing: L. M. Roth.

on the column) is roughly one-fourth the height of the column. The shaft of the Doric order rises directly from the stylobate platform; it has no base. The shaft itself has twenty broad scalloped indentions, or *flutes,* with sharp outer edges. Atop the shaft, the ***capital*** of the Doric column consists simply of a banded necking, a gently outward-swelling ***echinus***, and a final square ***abacus*** slab.

The more slender ***Ionic*** order [3.16] has an ornamental base, from which the shaft rises. The column itself is roughly nine times as high as its diameter, and the shaft has twenty-four flutes with flattened edges. The capital has unique curled ***volutes*** resting on an egg-and-dart molding; over the egg-and-dart molding is a swelling *pulvinus* (Latin for "pillow"), connecting the curling volutes. The Ionic entablature is roughly one-fifth the height of the column and is made up of an architrave of two or three vertical flat surfaces or faces, with a middle ***frieze***, most often filled with a continuous narrative band of relief sculpture. Atop this is the cornice.

Slightly more slender still is the ***Corinthian*** order [3.17], whose column is ten times the height of its diameter. It rises from a base similar to that of the Ionic order and, like it, normally has twenty-four flutes. The Corinthian capital is the tallest of the three, with two or three concentric bands of lush outward-curling acanthus leaves. The entablature is similar to that of the Ionic order.[2]



3.15. Doric capital (Parthenon, Athens). From: Stuart & Revett, Antiquities of Athens *(London, 1762).*