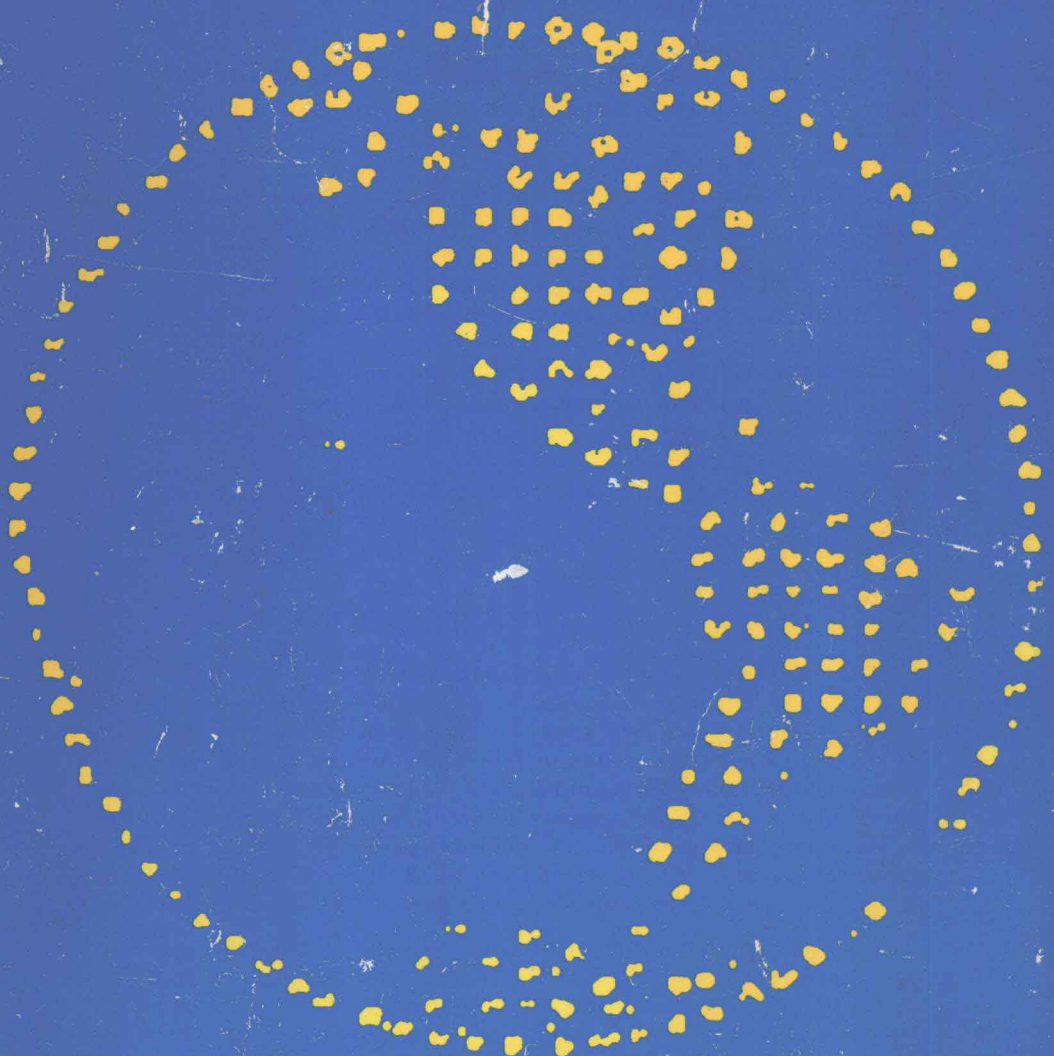
MAP USE

Reading • Analysis • Interpretation



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Third Edition

MAP USE

Reading, Analysis, and Interpretation

Third Edition

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To our delight, hundreds of people took the time to comment on these editions. Some of these people were merely lovers of maps; others were professors responsible for teaching introductory courses in map reading, analysis, and interpretation; and a number were students who had occasion to use the book in their studies. All these responses were useful and gratefully received.

We alone, of course, bear full responsibility for errors in the text and controversial statements. This work reflects our deep love of maps and a desire to help others bring maps into their lives.

P.C. and J.O. Muehrcke
Madison, Wisconsin

My object in living is to unite
My avocation and my vocation
As my two eyes make one in sight.

—Robert Frost

Preface

People whose professions it is to study, design, and make maps for the rest of us to use are called **cartographers**. From them we ask for little less than a miracle. We want the overwhelming detail, complexity, and proportion of our confusing surroundings reduced to a simple map representation which we can carry around with us conveniently but which will still provide us with a meaningful basis for relating to the environment.

It is fair to say that the cartographer has given us what we asked for. A vast array of subjects has been mapped in a variety of clever, even ingenious, ways. Advances in environmental data collection, processing, and graphic portrayal, with the annual support of millions of dollars of government and private funds, have made maps accessible to everyone. They not only cover almost any topic of interest for all parts of the world, but they are also remarkably low in cost.

Sadly enough, many of us have not acquired the basic skills necessary to take full advantage of these maps. We blunder through the environment, not appreciating what it has to offer, often causing hardship for ourselves and others, and all too frequently relating to our surroundings in a destructive way. This need not be the case. Learning to use a map is a relatively easy and painless process, with an immense payoff.

Numerous books on map making have been written. But since map use is not the simple reverse of map making, most of these books are of limited value to you as a map user. In contrast, this book, now in its third edition, has been written strictly for the person who wants to use maps. Academics have tended to treat maps as indoor things, rarely including in their textbooks the fact that one of the most exciting ways to use maps is in the field. Conversely, the numerous military manuals and field guides to map and compass use have focused narrowly on way finding, virtually ignoring the role which maps play in communicating environmental information. This book is an attempt to bridge the gap between these two extremes, to pull fragments of information from many fields into a coherent way of looking at the environment. It is an endeavor to provide a comprehensive, philosophical, and practical treatment of map appreciation. To do this, it has been necessary to deviate in several ways from approaches taken in previous cartographic literature.

First, we have extended the definition of a "map" so that it will include a variety of important map forms which are otherwise awkward to categorize. The definition of "map" adopted here should also readily accommodate any new cartographic forms which might be developed in the future. Throughout this book, we have integrated discussions of standard planimetric maps, perspective diagrams, environmental photographs, and satellite images, rather than partitioning each into a separate category.

Second, we have made a clear distinction between the tangible cartographic map and the mental or cognitive map of the environment which we hold in our heads. Ultimately, it is the map in our minds, not the map in our hands, with which we make decisions. Throughout the text, we stress the point that cartographic maps are valuable aids for developing better mental maps. We should strive to become so familiar with the environment that we can move through it freely in both a physical and mental sense. Ideally, our cartographic and mental maps should merge into one.

In a third departure from tradition, we have, where appropriate, made extensive reference to commercial products of special interest to the map user. A few years ago this would have seemed

strange, since most mapping was done by large government agencies. But times have changed. The field of mapping is rapidly being commercialized. Computer software and digital data for mapping are being developed and sold by private industry. What you do with maps in the future will very likely be influenced by the nature of these commercial products.

Our fourth break from established procedure has been to shift attention away from global map projections. Traditionally, a treatment of map use was almost synonymous with a discussion of map projections. Yet the use of a projection is only one of a multitude of ways in which reality is distorted and transformed when a map is made. Global map projections may be dramatic and mathematically elegant, but their impact on our everyday use of maps is relatively minor. Many people have been turned off to maps because they were forced to learn the names and characteristics of a long list of projections—information which had little to do with their lives. By devoting a smaller amount of space to projections, we have been able to explore topics more crucial to the general map user.

Finally, this book is not written in traditional textbook style. Only sparing reference is made within the text to the professional cartographic literature, and the selected readings at the end of each chapter are chosen as much for their general assessibility as their content. Whenever possible, examples and illustrations have been taken from popular sources. Maps touch so many aspects of our daily lives that it is simple and natural to make points and reinforce ideas with advertisements, cartoons, and quotations from everyday communications. These illustrations and examples are included to demonstrate and reinforce basic mapping and map use principles. They are thus an integral part of the book and should be given as much consideration as the text.

The book was designed for both the specialized and the general map user. It could be used as a basic reference work or as the textbook for a beginning map appreciation course in any of the environmental sciences. It has been specifically designed and tested for use in a three-credit semester course of 15 weeks at the college freshman level. Material is presented at the upper high school to intermediate college level.

While the basic philosophy behind *Map Use* has not changed in the third edition, readers will notice some major differences. The impact of electronic technology on the way maps are used has been addressed more directly throughout the text, and two chapters are devoted to computer mapping software. Some of the larger chapters in the previous edition have been divided into more focused, smaller units. A chapter on position and path finding has been added. Material on map interpretation has been reorganized and expanded. A number of changes have been made in the text and illustrations to incorporate changes which have occurred since the second edition was published. And, finally, suggested exercises have been added to the end of each chapter to provide a means for review and skill-building.

Our aim has been to cut through the plethora of confusing terms and details that characterize so many cartographic texts. Readers can obtain an overview of the most important concepts and how they fit together by glancing through the beginning outline and suggested exercises included for each chapter.

We have structured the material into three main sections under the headings *Map Reading* (Part I), *Map Analysis* (Part II), and *Map Interpretation* (Part III). In most books, these terms have not had more than vague definitions and are often used interchangeably. Here they have been defined precisely, and the relationship of each to the others has been made clear.

In *Part I, Map Reading*, we discuss the geographical data which make up a map, the process required to transform that information from environment to map, mapping techniques (image mapping, landform portrayal, attribute mapping, and statistical mapping), the temporal aspect of maps, and software for map retrieval. The goal in this section is to give the reader an appreciation of how the cartographer represents the environment in the reduced, abstract form of a map. In map reading, in a sense, we are trying to "undo" the mapping process in our minds.

Once we grasp the degree to which cartographic procedures can influence the appearance and form of a map, we are in a position to use maps to analyze the spatial structure and relations of the mapped environment. *Part II, Map Analysis*, includes chapters on reference systems, direction, dis-

tance, position and path finding, cartometrics, form and structure, pattern comparison, software for map analysis, and map accuracy. With each of these topics, the concern is on estimating, counting, measuring, data manipulation, and pattern-seeking activities.

Map analysis in itself serves some engineering functions but intellectually is rather sterile. The results of map analysis come alive when we try to explain why the environment takes on one spatial character over another. This is the subject of *Map Interpretation (Part III)*. The material has been divided into six chapters: "Interpreting the Physical Environment," "Interpreting the Human Environment," "Interpreting Environmental Interactions," "The Jigsaw Environment," "Image Map Interpretation," and "Maps and Reality." The emphasis in this final section is on environmental comprehension and understanding, for it is our surroundings, not the map, which is the real subject of map use.

These three parts are followed by a series of appendices. Topics include map scale, remote sensing of the environment, projections, navigational aids, useful mathematical tables, and computer hardware for the map user. Each appendix is designed to complement material presented in the main body of the text.

Although a systematic development of subject matter is followed throughout this book, each section and chapter is autonomous from, and cross-referenced to, the rest of the material. Therefore, it is not necessary to read the book in order from cover to cover. The strategy most appropriate for you depends on your background and interests. Generally, the book is organized to provide inexperienced readers with a logical development of concepts. There is a progressive building of skills from beginning to end. More experienced map users may wish to focus initially on sections or chapters of special interest and then refer to other parts to refresh their memories or to clarify terms, concepts, and methods.

This book will have served its purpose if readers finish it with a greater appreciation of maps than when they began. In even the simplest map, there is much to respect. Cartographers have managed to shape the jumble of reality into compact, usable form. They have done a commendable job. Now it is up to us.

MAP

It tells the truth by lying, like a poem
With bold hyperbole of shape and line—
A masterpiece of false simplicity.
Its secret meanings must be mulled upon,
Yet all the world is open to a glance.
With colors to fire the mind, a song of names,
A painting that is not at home on walls
But crumpled on a station wagon floor,
Worn through at folds, tape patched and chocolate smudged
(What other work of art can lead you home?)
—A map was made to use.

—Juliana O. Muehrcke

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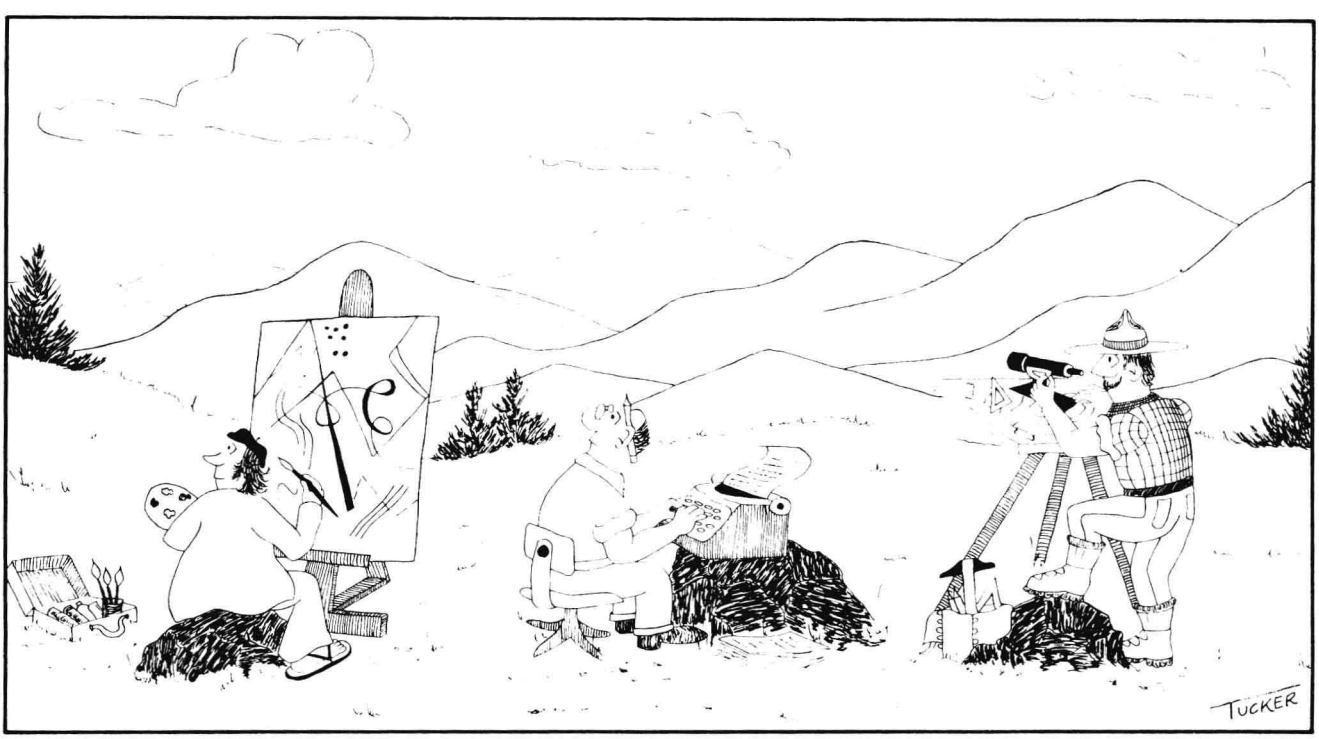


Map me no maps, sir, my head is a map of the whole world.

—Henry Fielding

Introduction

It should be easier to read a map than to read this book. After all, we know that a picture is worth a thousand words. Everyone from poets to the Internal Revenue (with its pamphlet entitled "Road Map to Form 1040A") works from the assumption that nothing could be more basic and easy to understand than a map. The very term "map" is ingrained in our thinking pattern. We use it often to convey the idea of clarification, as in "Map out your plan" or "Do I have to draw you a map?" How ironical, then, to write a book using language that is, supposedly, more complicated than the thing we are trying to explain!

The flaw in this reasoning is that maps are not nearly as simple and straightforward as they may seem at first glance. On the contrary, a map of our detailed and complexly interrelated surroundings tends to be quite mysterious and deceptive. This is not to say that maps themselves are unclear. But it is the mapped world, not the map, which we are trying to understand.

Making maps simple does not change the world; it only lets us treat it, for certain purposes, as if it were less complicated. There are many advantages in such a treatment, but there is also the danger that we will unknowingly end up with an unrealistic view of reality. All too often, in fact, such warped views of the environment are held by people who have responsibility for managing critical natural and human resources.

Furthermore, although maps are often thought to be easily—almost intuitively—understood, for many people they are not. Maps seem to be a source of frustration and panic just as often as they serve some useful function. For a large number of people, maps rank along with math problems as a cause of anxiety. This is lamentable, for such people are unable to appreciate the enormous benefits of using maps as educational aids and research tools and in day-to-day spatial problem-solving and orientation activities.

In this book, we will define a map as a **spatial representation of the environment**. By "representation," we mean something that stands for the environment, that portrays it, and is both a likeness and a simplified model. With this definition, we can encompass such diverse types of maps as those we hang on walls or hold in our hands and, at the other extreme, those held solely in the mind's eye. To appreciate why it is important to think of maps in such an all-encompassing sense, let us begin by taking a closer look at how we come to know the environment around us.

Knowing Our Surroundings

What we know about the environment is tied closely to the way we think and communicate in general. We do not gain environmental knowledge passively through mere absorption or some

"looking-and-knowing" insight. It comes through an active process of information gathering, structuring, and association. This process involves transformations of form and substance, which are bound to influence what we eventually know about our surroundings. The impact of this information processing can be better understood if we look at the stages involved, with emphasis on seeing.

Sensory Data

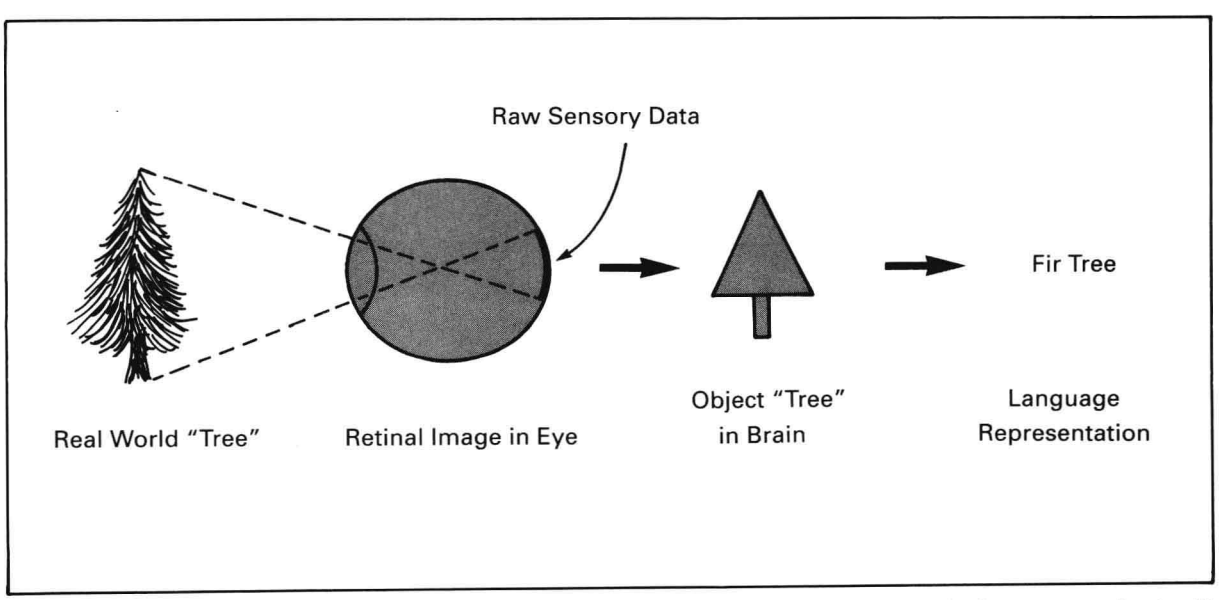
The most natural and basic way we learn to know our environment is through direct sensory data. Our senses of sight, sound, smell, taste, and touch have fine-tuned us to our surroundings through countless evolutionary generations. In the case of our eyes, light energy reflected from different locations in our field of view is picked up by cells in the retina that are sensitive to different colors. This provides the **raw sensory data** of seeing (**Figure I.1**).

Consider how different our conception of the environment might be if we could use x-ray, infrared, or microwave energy to see rather than depending solely on visible light. Obviously, the scope of what we see is limited. Sensory perception also requires direct contact with the object of sensation. In a world restricted to sensory data alone, everything must be experienced first-hand.

Conception

People do not limit themselves to raw sensory data, of course. Long ago we learned to think abstractly, which is rooted in the concept of **categorization.** Seeing involves far more than a mere recording of light energy on the millions of sensory cells in the retina of our eyes. These direct sensory data undergo cognitive filtering and processing that leads to object-oriented information in our brain (see Figure I.1). We see features such as buildings and trees, not tiny spots of varying color as recorded by the individual retina cells. In other words, our brain organizes bits of data into meaningful features. We might liken the retinal image to an aerial photograph, and the brain conception to a road map.

In practice, there are two views of categorization. In the classical view, members of a group all share certain similar properties. It follows that all members of a group are equally good examples, and categories exist independently of those doing the categorizing. This view underlies the technical view of perception, in which we simply see what is there to be seen. Our ability to categorize features such as roads



I.1 The process of seeing begins with light rays reflected from environmental features falling on the retina in your eye and ends with the conception and representation of objects in your brain.

and rivers, and similar rather discrete entities, is founded on this classical view of categorizing.

In contrast, the modern view of categorization is based on the idea that categories have best examples called **prototypes**, and the categorizing process cannot be separated from human experience and imagination. Realism is experiential, not given. Our willingness to accept such concepts as climate and soil class is founded on this modern view of categorizing.

Categories, regardless of the type, enormously simplify our view of the environment. The aim is to use as little energy as possible to process the massive volumes of visual sense data and yet still pick up the essence of a visual scene. In other words, to speed information handling for purposes of survival, we have learned to "enrich" raw sensory data. This is done by converting locational sensations on the retina into objects or features.

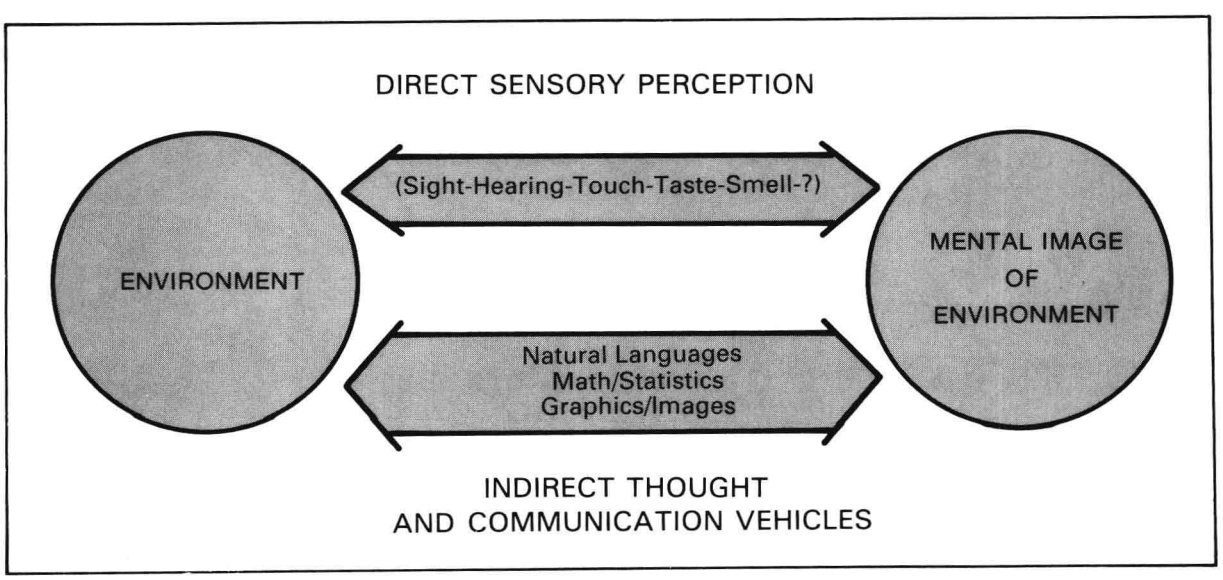
Representation

Categorization is only one component of thinking abstractly, however. Communication requires some mechanism for knowledge representation. Rather than pointing at actual features, we need something to stand for these features. For this purpose we invented symbols (see Figure I.1).

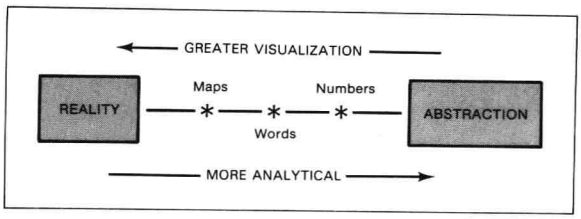
Evidence of our use of symbols to stand for physical objects dates back about 30,000 years. Symbols were soon being used to represent abstract concepts as well. This use of symbols set the basis for our development and use of natural languages, mathematics, statistics, and pictorial vehicles of thought and communication (**Figure I.2**). To a large extent, these devices have allowed us to overcome our sensory and perceptual limitations.

Natural languages, such as English or German, are by far the most highly developed and widely used of these aids. People in every society have learned to interact with the environment with the help of words. Mathematics or formal logic represents a more abstract and rigorous vehicle, in which aspects of the environment are reduced to numbers. The branches of mathematics are often referred to as **artificial languages**. **Pictures**, both **graphics** and **images**, which are less abstract than natural languages and mathematics, constitute still a third indirect thinking aid.

Just as is true of our senses, each of these indirect means of environmental thought is itself limited in scope and sensitivity. No single method best serves all purposes. In fact, words, numbers, and pictures occupy complementary positions along an abstraction gradient (**Figure I.3**).



I.2 Humans are unique in learning to know their environment by supplementing raw sense data with indirect vehicles of thought and communication.



I.3 If we arrange graphics, words, and numbers along an abstraction gradient, we can see that the closer they fall toward reality the greater their visualization power, while greater abstraction better serves analytical purposes.

We employ these abstractions in two main ways when thinking about the environment. At one extreme, we may conceive of our surroundings in holistic, spatial terms, with everything occurring at once and in complete interrelation. This is the view of the visual arts and Eastern philosophy. Graphics serve this function well. Or, in contrast, we may conceive of the environment in analytical terms, with the whole made up of component parts which can be identified, isolated, and manipulated separately. This is the view of Western scientific thought. The formal logic of mathematics serves this function well.

Although these analytical-spatial characterizations are rather crude generalizations, many people do seem to prefer one or the other of these approaches to environmental understanding. In this book we will stress a flexible use of both approaches, as such a complementary mix accentuates the strengths while minimizing the limitations of each taken alone. The ability to transfer thinking readily from one strategy to the other is an especially desirable skill to master.

Environmental Visualization

In this book we will be focusing on the pictorial vehicle of thought and communication and, in particular, cartographics. These pictorial devices serve the need for visualization which is the very foundation of intuition and creativity. Environmental visualization may be strictly mental and intangible, or it may take the more concrete form of a physical map or chart.

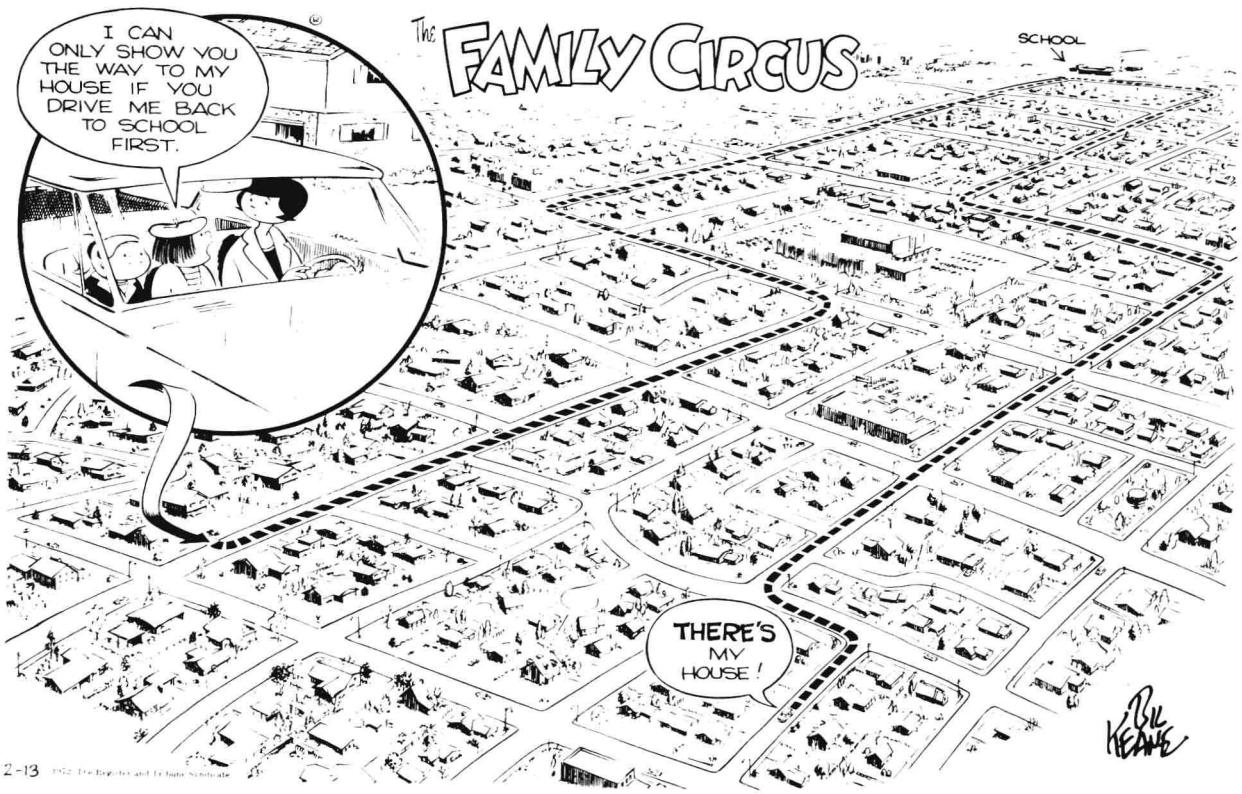
The maps in our minds, known as **cognitive or mental maps**, are often slighted in map definitions. Yet they are really the ultimate maps, because they are the ones we use to make decisions about the environment. Unfortunately, however, our mental maps are restricted in scope and often fail. When this happens, it is convenient to rely on the environmental portrayals of the map maker, or **cartographic maps.** Let us take a closer look at these two types of maps, beginning with the environmental images we hold in our minds.

Mental Maps

We come to grips with the world around us through the process of **cognitive mapping.** This mental activity begins before birth and continues for the remainder of our lives. Even as we crawled around as babies, we were constantly storing up impressions about the environment. Information about our surroundings were gathered through our senses of touch, sight, sound, smell, and taste—in other words, through **direct experience**. In addition, as we learned where things were, we naturally related them to our own position, because we assumed that we were the absolute center of things. Thus, as infants, our mental maps were **egocentric** in perspective.

As we explored further, we learned how to get from our crib to the couch to the kitchen and back again. This sequential exploration of our surroundings led to a network of familiar pathways along which environmental features were arranged one after another. Remembering the pathways, and the sequence of features that could be expected along each, allowed us as babies to move about in the environment in restricted but quite effective fashion. Nearby surroundings were usually explored more thoroughly than distant ones and were therefore more familiar, although there might have been large gaps in spatial awareness even in our immediate neighborhood if a pathway had not taken us there.

This, then, is the most primitive type of mental map—one based on direct experience, egocentricism, and a system of connected paths. The concept is summarized by the cartoon in **Figure I.4.** As adults, we can appreciate the humor in this cartoon because we see how inefficient these primitive mental maps can be. But the truth is that we still resort to this way of structuring our environment when we are thrown into unfamiliar settings. If we go for a walk in a strange city, we will remember how to get back to our hotel by putting connective



I.4 The geometry of a child's mental map is based on direct experience and consists primarily of topological relations between routes and locations.

information together into a pathway. Our mental map will be narrow and striplike, resembling a ribbon with a few landmarks like beads strung along it.

Most of our mental maps are more complicated than this, however. For one thing, we soon learn to take advantage of **indirect** as well as direct experience. We acquire information through T.V., conversations, photographs, reading, and other secondary sources. We transcend our physical limitations and are able to conceptualize distant environments, even those at the other side of the planet. Our mental map becomes surprisingly complex as it expands to encompass places we have never seen.

At the same time, the baby's egocentric view of the environment is slowly lost (for most of us) as we face the facts of life and realize that we're not the center of the universe. It is replaced by a **geocentric** point of view. Rather than relating everything to our own location, we learn to orient ourselves with respect to the external environment. Thus, we can assume ourselves to be at distant positions, even when we have not moved physically. The feat might be called the geographical "What if...?"

Once we learn to separate ourselves from our environment, we no longer need to structure our mental maps in terms of connected pathways. We can have a mental map of a scene without being an intimate part of it. We can visualize how to get from one place to another "as the crow flies"—the way we would go if we weren't restricted to established routes or constrained by obstacles which impede free movement. Indeed, it is our ability to see the "big picture," to have a broad and comprehensive mental map, that makes the cartoon in Figure I.4 amusing.

Our geocentric viewpoint, with its freedom from the constraints of sequential pathway imagery, is given a major boost when we learn to use an established frame of spatial reference which we can share with others. The system of