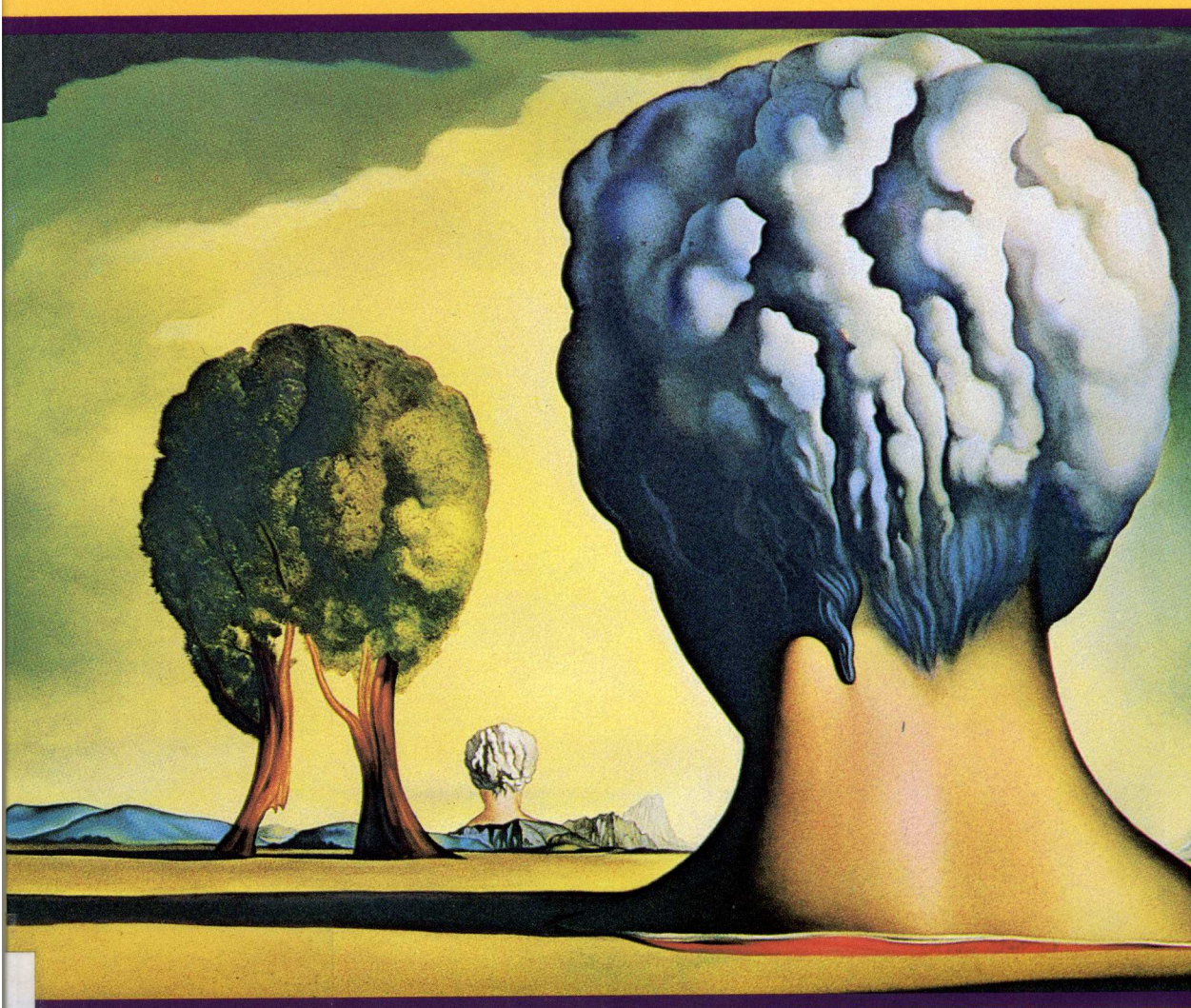
THE TREE OF KNOWLEDGE

The Biological Roots of Human Understanding

Revised Edition



Humberto R. Maturana, Ph.D
& Francisco J. Varela, Ph.D

FOREWORD BY J. Z. YOUNG

"A beautiful and clearly-written guide to thought and perception—something that, like life itself, we take for granted but do not understand. The authors were the pioneers and are now the authoritative figures in the science of cognition: their book is rewarding, thorough, and very readable to anyone curious about the mind and the way that it works."

—JAMES LOVELOCK, author of *Gaia: A New Look at Life on Earth*

"The ideas presented in this book are radical and exciting, disturbing and challenging. For the first time we are shown the outlines of a unified *scientific* conception of mind, matter, and life. The fruits of Maturana and Varela's *Tree of Knowledge* include the central insight that cognition is not a representation of the world 'out there,' but rather a 'bringing forth of the world through the process of living itself,' and the stunningly beautiful conclusion: 'We have only the world that we can bring forth with others, and only love helps bring it forth.'"

—FRITJOF CAPRA, author *The Tao of Physics*

"KNOWING HOW WE KNOW" is the subject of this book. Its authors present a new view of cognition that has important social and ethical implications, for, they assert, the only world we humans can have is the one we create together through the actions of our coexistence.Written for a general audience as well as for students, scholars, and scientists and abundantly illustrated with examples from biology, linguistics, and social and cultural phenomena, this revised edition includes a new afterword by Dr. Varela, in which he discusses the effect the book has had in the years since its first publication.

HUMBERTO R. MATURANA, PH.D., is a biologist who teaches at the University of Chile. He is also co-author with Dr. Varela of *Autopoiesis and Cognition: The Realization of the Living*.

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COVER ART: *The Three Sphinxes of Bikini* (1947) by Salvador Dali. Oil on canvas, 30 × 50 cm, Galerie Petit, Paris. Copyright Demart Pro Arte B.V./Salvador Dali, Photograph by Robert Descharnes. Reproduced with permission.

Contents

Foreword

This book will start readers thinking in new ways about both science and philosophy. The authors have been most ingenious in finding means to explain at the same our human processes of thought and the facts of biology. There are fresh insights on every page, presented very clearly. Dr. Maturana and Dr. Varela, well known for finding new approaches in nerve physiology, have produced a truly original book, which will be a revelation and inspiration to many people.

Professor J. Z. YOUNG
Oxford University

Preface

The book that you now hold in your hands is not just another introduction to the biology of cognition. It is a complete outline for an alternative view of the biological roots of understanding. From the outset we warn readers that the view presented here will not coincide with those they are likely to be familiar with. Indeed, we will propose a way of seeing cognition not as a representation of the world "out there," but rather as an ongoing bringing forth of a world through the process of living itself.

To accomplish this goal, we shall follow a rigorous conceptual itinerary, wherein every concept builds on preceding ones, until the whole is an indissociable network. We thus discourage a casual, diagonal reading of this book. In compensation, we have done our best to provide a wealth of illustrations and a conceptual map of salient ideas, clearly indicated in the text as separate boxes, so that readers can always find where they are standing along the journey.

This book came into being as a consequence of very particular circumstances. In 1980 the Organization of American States (OAS) was actively seeking ways to understand the many difficulties confronted in social communication and knowledge transfer. Aware of this need, Rolf Benhcke,

then with ODEPLAN (the Ministry of Planning of the Chilean government), immediately thought it would be beneficial to expose the OAS to our approach to those issues, in the form of a coherent formulation of the foundations of communication as the biological being of man. The OAS accepted the idea, and a contract was signed. The project began in September 1980 with a series of lectures delivered to an audience of mostly social workers and managers, given alternately by both authors. These lectures were transcribed, extensively edited during 1981–1983, and published as a book printed privately in 1985 for the internal distribution of OAS. Excepting some minor corrections and additions, that initial text is the present book. Thus, we are very grateful to the OAS for its interest and financial support and for giving us the freedom to publish the text independently. Most particularly we are indebted to Mr. Benhcke, who put heart and soul into seeing this project come to fruition. Finally, Francisco Olivares and his associates, who labored for months over the many illustrations of this book, should be acknowledged with many thanks for their excellent performance. Without the concurrence of each and all of these persons and institutions, this book would not have been possible.

A word about the history of the ideas contained in this book is also in order. They can be traced back to 1960, when Humberto Maturana began to depart from habitual biological tradition and tried to conceive of living systems in terms of the processes that realized them, and not in terms of the relationship with an environment. That exploration continued over the next decade and attained a first clear manifestation in his article "The Neurophysiology of Cognition,"[1] published in 1969, in which some of the key ideas on the circular organization of living system were expounded. Fran-

1. H. R. Maturana, "The Neurophysiology of Cognition," in P. Garvin, *Cognition: A Multiple View* (New York: Spartan Books, 1969). The final version of this paper appeared as H. R. Maturana, "The Biology of Cognition," BCL Report no. 9.0, 1970, reprinted in *Autopoiesis and Cognition* (see footnote 3).

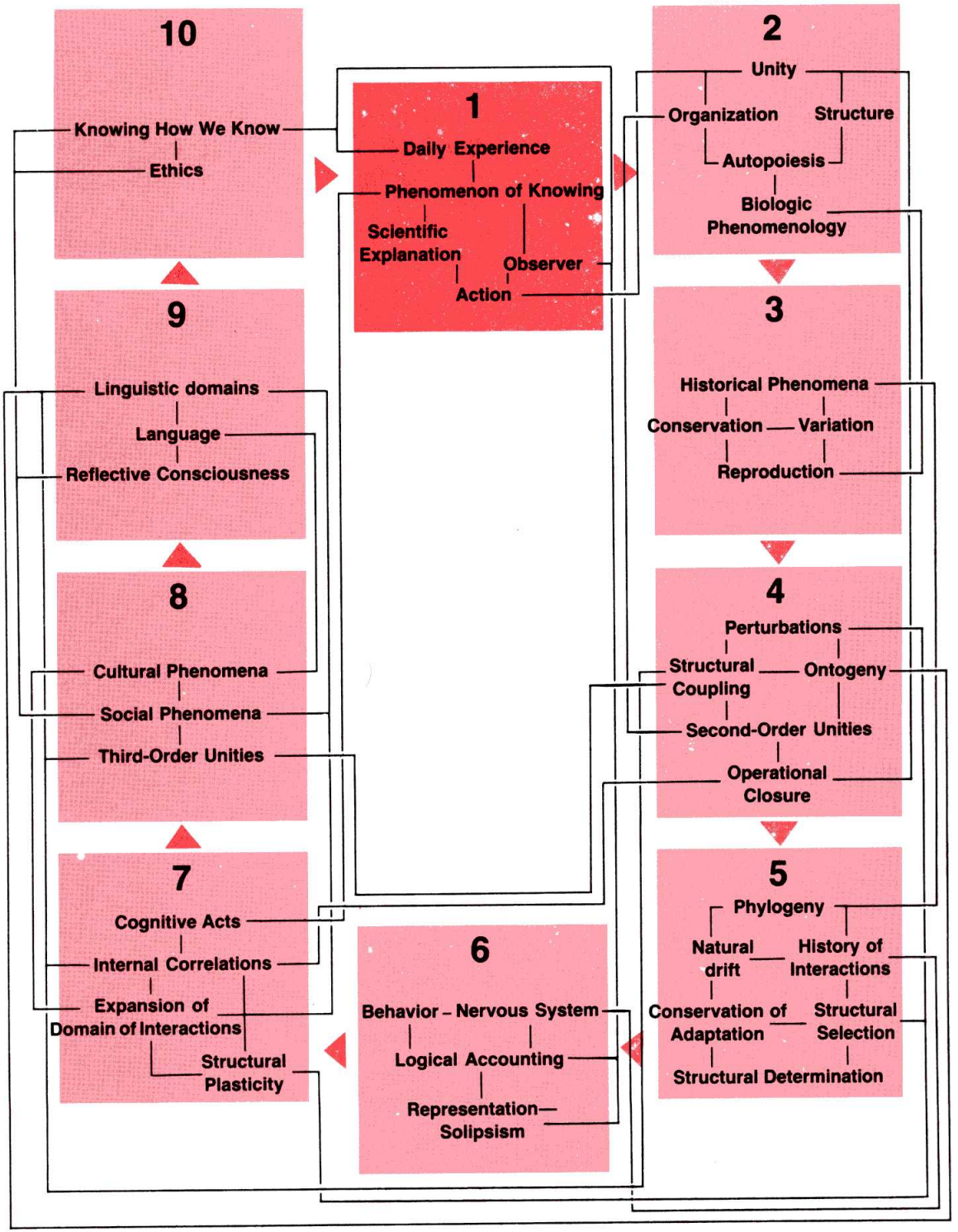
cisco Varela had started as Maturana's student in the mid-1960s, and by 1970, the two of us, now working as colleagues at the University of Chile, continued on the trail to produce a reformulation of the biological phenomenology in a small book entitled *Autopoiesis: The Organization of the Living*, written during 1970–1971 and first published in 1973.[2] Both these "foundational" papers are now available in the book *Autopoiesis and Cognition*.[3] The political events in Chile in 1973 led both of us to continue our research in distant places and in our own styles, covering new theoretical and experimental ground.[4] Much later, in 1980, when circumstances again made it possible, our collaboration was resumed in Santiago. The present book incorporates ideas developed independently or jointly by both of us during all these years. It represents in our eyes a fresh, accessible synthesis of a view of life and mind that we have come to share, starting from the early intuitions of Maturana more than twenty-five years before.

More than anything, this text is an invitation for readers to let go of their usual certainties and thus to come into a different biological insight of what it is to be human.

2. H. R. Maturana and F. J. Varela, *De máquinas y seres vivos: Una teoría de la organización biológica* (Santiago, Editorial Universitaria, 1973). English version in *Autopoiesis and Cognition* (see footnote 3).

3. H. Maturana and F. Varela, *Autopoiesis and Cognition: The Realization of the Living* (Boston: D. Reidel, 1980).

4. See, for example, H. R. Maturana, "Biology of Language: Epistemology of Reality," in *Psychology and Biology of Language and Thought*, ed. G. Miller and E. Lenneberg (New York: Academic Press, 1978); F. J. Varela, *Principles of Biological Autonomy* (New York: North-Holland, 1979).


10
Knowing How We Know
Ethics
1
Daily Experience
Phenomenon of Knowing
Scientific Explanation
Observer
Action
2
Unity
Organization
Structure
Autopoiesis
Biologic Phenomenology
9
Linguistic domains
Language
Reflective Consciousness
3
Historical Phenomena
Conservation
Variation
Reproduction
8
Cultural Phenomena
Social Phenomena
Third-Order Unities
4
Perturbations
Structural Coupling
Ontogeny
Second-Order Unities
Operational Closure
7
Cognitive Acts
Internal Correlations
Expansion of Domain of Interactions
Structural Plasticity
6
Behavior – Nervous System
Logical Accounting
Representation—Solipsism
5
Phylogeny
Natural drift
History of Interactions
Conservation of Adaptation
Structural Selection
Structural Determination

1 Knowing How We Know

The Great Temptation

In Figure 1 we admire *Christ Crowned with Thorns* by the master from 's-Hertogenbosch, better known as Bosch. This untraditional portrayal of the crowning with thorns depicts the scene almost in a flat plane, with large heads. More than a single incident in the Passion, it suggests a universal sense of evil contrasted with the kingdom of heaven. Christ, in the center, expresses the utmost patience and acceptance. His tormentors, however, were not painted here, as in so many other works in the time and by Bosch himself, with otherworldly figures directly attacking Christ, pulling his hair or piercing his flesh. The attackers appear as four human types that in the medieval mind represented a total view of humanity. Each one of these types is like a great temptation against the expansiveness and patience of Christ's expression. They are four styles of estrangement and loss of interior calm.

Fig. 1. *Christ Crowned with Thorns* by Hieronymus Bosch, National Museum of the Prado, Madrid.

There is much to meditate on and contemplate about in these four temptations. For us who are beginning the long journey of this book, however, the figure at the lower right is particularly relevant. He is grabbing Jesus by the robe, tugging him to the ground. He holds on to him and restricts his freedom, fastening his attention on him. He seems to be telling him: "Now listen to

me, I know what I'm saying!" This is the temptation of *certainty.*

We tend to live in a world of certainty, of undoubted, rock-ribbed perceptions: our convictions prove that things are the way we see them and there is no alternative to what we hold as true. This is our daily situation, our cultural condition, our common way of being human.

Now, this whole book is a sort of invitation to refrain from the habit of falling into the temptation of certainty. This is necessary for two reasons. On the one hand, if the reader does not suspend his certainties, we cannot communicate anything here that will be embodied in his experience as an effective understanding of the phenomenon of cognition. On the other hand, what this book aims to show, by scrutinizing the phenomenon of cognition and our actions flowing from it, is that all cognitive experience involves the knower in a personal way, rooted in his biological structure. There, his experience of certainty is an individual phenomenon blind to the cognitive acts of others, in a solitude which, as we shall see, is transcended only in a world created with those others.

Surprises of the Eye

Nothing we are going to say will be understood in a really effective way unless the reader feels personally involved and has a direct experience that goes beyond all mere description.

So, instead of telling why the apparent firmness of our experiential world suddenly wavers when we look at it up close, we shall demonstrate this with two single examples. Both correspond to the sphere of our daily visual experience.

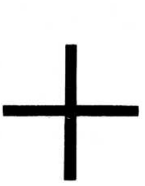
First example: Cover your left eye and stare at the cross in Figure 2. Hold the page about fifteen inches away from you. You'll notice the black dot in the drawing, not small in size, suddenly disappear. Experiment by rotating the page a bit or opening your other eye. It is also interesting to copy the drawing on another sheet of paper and gradually enlarge the black dot until it reaches the maximum size at which it disappears. Further, rotate the page so that point B is in the place where point A was, and repeat the observation. What happened to the line that crosses the dot?

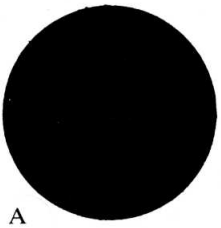
Actually, this same situation can be observed without any drawing: simply replace the cross on the dot with your thumb. The thumb looks as if it is cut off. (Try it!) Incidentally, this is how the observation became popular: Marriot, a scientist at the French court, showed King Louis by this process how his subjects would look beheaded before he had their heads cut off.

The commonly accepted explanation of this phenomenon is that the image of the dot (or the thumb or the subject), in that specific position, falls into the area of the retina where the optic nerve emerges; hence, it is not sensitive to light. It is called the blind spot. What is rarely stressed in giving this explanation, however, is: How come we don't go around with a hole that size all the time? Our visual experience is of a continuous space. Unless we do these ingenious manipulations, we will not perceive the discontinuity that is always there. The fascinating thing about the experiment with the blind spot is that *we do not see that we do not see.*

Second example: Let us take two sources of light and place them as in Figures 3 and 4. (This can be done by making a paper tube the size of a strong

Fig. 2. Experiment of the blind spot.





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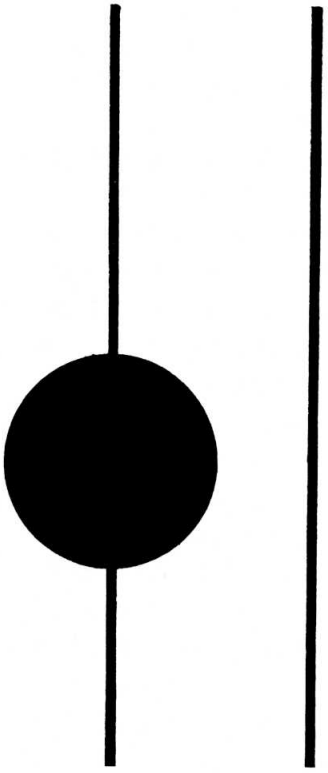

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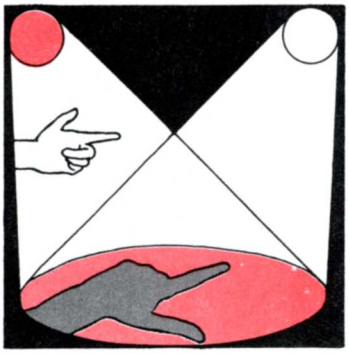


Fig. 3.

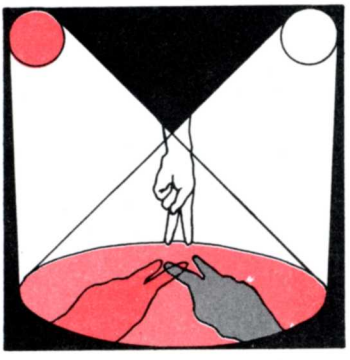


Fig. 4.

light bulb and using some red cellophane as a filter.) Then place an object, such as your hand, in the beam of light. Note the shadows on the wall. One of the shadows looks bluish-green in color! The reader can experiment by using different-colored transparent papers in front of the lights and different light intensities.

The example here is as surprising as in the case of the blind spot. Why do we get a bluish-green color when we simply expected white, red, and mixtures of white with red (pink)? We are used to thinking that color is a quality of objects and of the light they reflect. Thus, if I see green, it must be because a green light is reaching my eye, that is, light of a certain wavelength. Now, if we take an instrument to measure the light composition in this example, we find that there is no predominance of wavelengths called green or blue in the shadow we see as bluish-green, but only the distribution proper to white light. Our experience of greenish-blue, however, is something we cannot deny.

This beautiful phenomenon of the so-called colored shadows was first described by Otto von Guericke in 1672. He noted that his finger appeared blue in the shadow between the light from his candle and the rising sun. Confronted with this and similar phenomena, people usually say: "Fine, but what color is it *really?*—as though the answer given by the instrument that measures wavelengths were the ultimate answer. Actually, this simple experiment does not reveal an isolated situation that could be called (as is often the case) marginal or illusory. Our experience with a world of colored objects is literally independent of the wavelength composition of the light coming from any scene we look at. In point of fact, if I take an

orange from my room to the patio, the orange still seems to be of the same color; however, the inside of the house was illumined by flourescent light, which has a great number of so-called blue (or short) wavelengths, whereas the sun has mostly so-called red (or long) wavelengths. There is no way we can trace a correspondence between the great color consistency of the objects we see and the light that comes from them. It is not easy to explain how we see colors, and we shall not try to do so here in detail. But the important thing, to explain it, is for us to stop thinking that the color of the objects we see is determined by the features of the light we receive from the objects. Rather, we must concentrate on understanding that the experience of a color corresponds to a specific pattern of states of activity in the nervous system which its structure determines. In fact, although we shall not do it right now, we can demonstrate that because these states of neuronal activity (as when we see green) can be triggered by a number of different light perturbations (like those which make it possible to see colored shadows), we can correlate our naming of colors with states of neuronal activity but not with wavelengths. What states of neuronal activity are triggered by the different perturbations is determined in each person by his or her individual structure and not by the features of the perturbing agent.

The foregoing is valid for all the dimensions of visual experience (movement, texture, form, etc.), as also for any other perceptual modality. We could give similar examples that show us, at one stroke, that what we took as a simple apprehension of something (such as space or color) has the indelible mark of our own structure. We shall have to content ourselves for now with the observations

given. We trust that the reader has tested them. Therefore, we assume that the reliability of his or her experience has been shaken.

These experiences—and many others like them—contain in a nutshell the essential flavor of what we wish to say. That is, they show how our experience is moored to our structure in a binding way. We do not see the "space" of the world; we live our field of vision. We do not see the "colors" of the world; we live our chromatic space. Doubtless, as we shall note throughout these pages, we are experiencing a world. But when we examine more closely how we get to know this world, we invariably find that we cannot separate our history of actions—biological and social—from how this world appears to us. It is so obvious and close that it is very hard to see.

A Crying Shame

In the Bronx Zoo in New York City there is a special pavilion for primates. There we can see chimpanzees, gorillas, and many monkeys of the Old and New Worlds. Our attention is drawn, however, to a separate cage at the back of the pavilion. It is enclosed with thick bars and bears a sign that says: "The Most Dangerous Primate in the World." As we look between the bars, we see with surprise our own face; the caption explains that man has destroyed more species on the earth than any other animal known. From being observers we go on to be the observed (by ourselves). But what do we see?

The moment of reflection before a mirror is always a peculiar moment: it is the moment when we become aware of that part of ourselves which we cannot see in any other way—as when we re-

veal the blind spot that shows us our own structure; as when we suppress the blindness that it entails, filling the blank space. Reflection is a process of knowing how we know. It is an act of turning back upon ourselves. It is the only chance we have to discover our blindness and to recognize that the certainties and knowledge of others are, respectively, as overwhelming and tenuous as our own.

This special situation of knowing how we know is traditionally elusive for our Western culture. We are keyed to action and not to reflection, so that our personal life is generally blind to itself. It is as though a taboo tells us: "It is forbidden to know about knowing." Actually, not knowing what makes up our world of experience, which is the closest world to us, is a crying shame. There are many things to be ashamed about in the world, but this ignorance is one of the worst.

Maybe one of the reasons why we avoid tapping the roots of our knowledge is that it gives us a slightly dizzy sensation due to the circularity entailed in using the instrument of analysis to analyze the instrument of analysis. It is like asking an eye to see itself. Figure 5, a drawing by the Dutch artist M. C. Escher, shows this dizziness very clearly: hands are drawing each other in such a way that the origin of the process is unknown: Which is the "real" hand?

Likewise, although we saw that the processes involved in our activities, in our makeup, in our actions as human beings, constitute our knowledge, we intend to investigate how we know, by looking at these things by means of those processes. We have no alternative, however, because what we do is inseparable from our experience of the world with all its regularities: its commercial

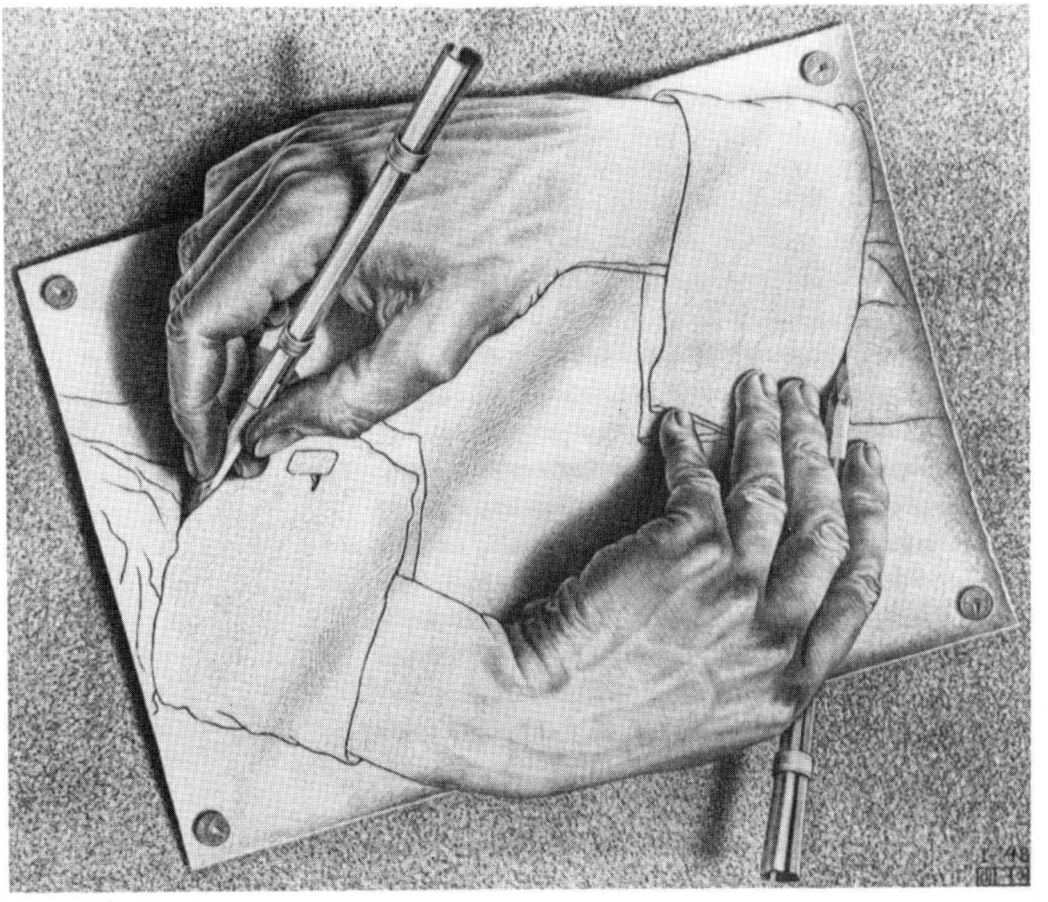


Fig. 5. *Drawing Hands* by M. C. Escher.

centers, its children, its atomic wars. What we do intend—and the reader should make it a personal task—is to be aware of what is implied in this unbroken coincidence of our being, our doing, and our knowing. We shall put aside our daily tendency to treat our experience with the seal of certainty, as though it reflected an absolute world.

Therefore, underlying everything we shall say is this constant awareness that the phenomenon of knowing cannot be taken as though there were "facts" or objects out there that we grasp and store in our head. The experience of anything out

there is validated in a special way by the human structure, which makes possible "the thing" that arises in the description.

This circularity, this connection between action and experience, this inseparability between a particular way of being and how the world appears to us, tells us that *every act of knowing brings forth a world*. This feature of knowing will invariably be our problem, our starting point, and the guideline of all that we present in the following pages. All this can be summed up in the aphorism *All doing is knowing, and all knowing is doing*.

When we speak here of action and experience, we mean something different from what occurs only in relation to the surrounding world, on the purely "physical" level. This feature of human activity applies to all the dimensions of our daily life. In particular, it applies to what we—the reader and the writer—are doing right here and now. And what are we doing? We are dealing in language, breezing along in a distinctive way of conversing in an imagined dialogue. Every reflection, including one on the foundation of human knowledge, invariably takes place in language, which is our distinctive way of being human and being humanly active. For this reason, language is also our starting point, our cognitive instrument, and our sticking point. It is very important not to forget that circularity between action and experience applies also to what we are doing here and now. To do so would have serious consequences, as the reader will see further on. At no time should we forget this. And to this end, we shall sum it all up in a second aphorism that we should keep in mind throughout this book: *Everything said is said by someone*. Every reflection brings forth a world. As

Key Sayings

"All doing is knowing and
all knowing is doing."

"Everything said is said by someone."

such, it is a human action by someone in particular in a particular place.

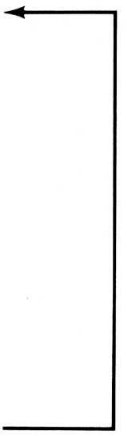
These two aphorisms ought to be like two guiding lights that permanently remind us where we came from and where we are going.

This bringing forth of knowledge is commonly regarded as a stumbling block, an error or an explanatory residue to be eradicated. This is why, for instance, a colored shadow is said to be an "optical illusion" and why "in reality" there is no color. What we are saying is exactly the opposite: this characteristic of knowledge is the master key to understanding it, not an annoying residue or obstacle. Bringing forth a world is the burning issue of knowledge. It is associated with the deepest roots of our cognitive being, however strong our experience may be. And because these roots go to the very biologic base—as we shall see—this bringing forth of a world manifests itself in *all* our actions and all our being. Certainly, it manifests itself in all those actions of human social life where it is often evident, as in the case of values and preferences. But there is no discontinuity between what is social and what is human and their biological roots. The phenomenon of knowing is all of one piece, and in its full scope it has one same groundwork.

Explanation

Our objective is then clear; we wish to examine the phenomenon of cognition by considering the universal nature of "doing" in cognition—this bringing forth of a world—as our problem and starting point, so as to show its foundation. And what will be our yardstick for saying that we have been successful in our attempt? An explanation is always a proposition that reformulates or recreates the observations of a phenomenon in a system of concepts acceptable to a group of people who share a criterion of validation. Magic, for instance, is as explanatory for those who accept it as science is for those who accept it. The specific difference between a magical explanation and a scientific one lies in the way a system of scientific explanations is made, what constitutes its criterion of validation. Thus, we can distinguish four conditions essential to proposing a scientific explanation. They do not necessarily fall in sequential order but do overlap in some way. They are:

a. Describing the phenomenon (or phenomena) to be explained in a way acceptable to a body of observers
b. Proposing a conceptual system capable of generating the phenomenon to be explained in a way acceptable to a body of observers (explanatory hypothesis)
c. Obtaining from (b) other phenomena not explicitly considered in that proposition, as also describing its conditions for observation by a body of observers
d. Observing these other phenomena obtained from (b).



Only when this criterion of validation is satisfied will the explanation be a scientific one, and a

Knowing

Knowing is effective action, that is, operating effectively in the domain of existence of living beings.

Explaining Cognition

I. Phenomenon to be explained: the effective action of a living being in its environment
II. Explanatory hypothesis: autonomous organization of living beings; phylogenetic and ontogenetic drift with conservation of adaptation (structural coupling)
III. Obtaining other phenomena: behavioral coordination in interactions recurring between living beings and recursive behavioral coordination upon behavioral coordination
IV. Further observations: social phenomena, linguistic domains, language, and self-consciousness

statement is a scientific one only when it is based on scientific explanations.

This four-component cycle is not alien to our daily thinking. We often use it to explain phenomena as varied as the breakdown of an automobile or the election of a president. What scientists do is try to be wholly consistent and explicit with each one of the steps. They will keep a record so as to create a tradition that will go beyond one person or one generation.

Our situation is exactly the same. We, the readers and the writers, have become observers who make descriptions. As observers, we have focused on cognition as our phenomenon to be explained. Moreover, what we have said points to our starting description of the phenomenon of cognition. Since all cognition brings forth a world, our starting point will necessarily be the operational effectiveness of living beings in their domain of existence. In other words, our starting point to get an explanation that can be scientifically validated is to characterize cognition as an *effective action*, an

action that will enable a living being to continue its existence in a definite environment as it brings forth its world. Nothing more, nothing less.

And how can we tell when we have reached a satisfactory explanation of the phenomenon of knowing? Well, by now the reader can guess the answer: when we have set forth a conceptual system that can *generate* the cognitive phenomenon as a result of the action of a living being, and when we have shown that this process can produce living beings like ourselves, able to generate descriptions and reflect on them as a result of their fulfillment as living beings operating effectively in their fields of existence. From this explanatory proposition we shall have to see just how all our familiar dimensions of knowing are generated.

This is the odyssey we set for the reader in these pages. Throughout the chapters that follow, we shall be developing both this explanatory proposition and its connection to additional phenomena such as communication and language. At the end of this journey, the reader can go over these pages again and assess how fruitful it was to accept our invitation to look thus at the phenomenon of knowing.