

# Preface to the Second Edition: The Nature of Life

What you are holding in your hands is a book about biology. About LIFE. It is a book that describes and elucidates, in scientific terms, the causal forces underlying the unique nature of all living organisms. It presents a set of rigorous and logical interlocking ideas which make clear what is generating the familiar behavior patterns we can observe in ourselves and all around us, everyday, and which characterize “life” as a systemic quality or feature of a system.

## Life is Anticipatory

Living organisms have the equivalent of one “foot” in the past, the other in the future, and the whole system hovers, moment by moment, in the present – always on the move, through time. The truth is that *the future* represents as powerful a causal force on current behavior as the past does, for all living things. And information, which is often presumed to be a figment of the human mind or at least unique to the province of human thought and interaction, is actually an integral feature of life, itself – even at the most fundamental level: that of system organization.

These are all findings which are described and elaborated here and, in my opinion, this particular book represents the most important of my father’s scientific discoveries. The development of this aspect of his larger theoretical work on relational complexity (lately being called “Relational Science”) is able to explain what have, heretofore, remained the most baffling and inexplicable of organismic living behaviors. It also demonstrates how and why the clues have been missed by science for so long. The current, purely reactive, paradigm for science is able to do many things but it cannot be expected to help us adequately with problems and questions pertaining to living systems if living systems are not merely reactive. This becomes a critical issue because science represents the set of tools humanity uses for exploring and understanding ourselves, our universe, and our place in the web of life here on Earth. We need to be able to trust our tools to help us solve problems in the biosphere without generating side effects worse than the problems, themselves.

Every living organism comes into being with a system-based value for *health*. Emerging from that value for health is a guiding principle that is equally individual: *optimality*. The functional capabilities of life – metabolism and repair – are entirely guided by these two values. What is clear from the outset is that the values pre-exist the business of living. Perhaps *time* is not quite as linear as we have always presumed it to be. My father's view, in fact, was that, "Time is complex."

According to Robert Rosen, the means by which a living system is internally guided and controlled involves encoded information acting as an interactive set of models – of self, of environment, and of relations between the two... through time. These models have the capacity to *predict* next behavior (of self and/or of native environment) based on current behavior. The fact that these are model predictions, as opposed to prescience or prophesy, can be proven by studying the peculiar error behaviors that arise when the encoded information being used in the models no longer accurately represents the systems it was encoded from. For example, if the environment changes, quickly and radically, from the way it has been throughout the recent evolutionary past, the models will no longer be able to reliably predict next behavior of environment from current behavior.

This is what happens when an organism is moved from its native environment and transplanted to some new environment, as in the case of "annual" plants and flowers sold in my neighborhood in Western New York State. Or tropical plants and trees grown indoors in pots, here. Many of these plants are not really annuals, but perennials which can live for many years, sometimes decades and (in the case of trees) centuries. However, they come from environments that never have had a winter like ours, and therefore have no information about it, either. Native plants begin to enter dormancy in mid to late August, here, triggered by various environmental cues such as changing day/night length, but the "annuals" bloom merrily away in pots and in the garden right up until the first freeze kills them outright.

Another proof that these are models can be demonstrated by observing that they can be "fooled." The horticultural industry uses this situation to very good effect: Producing Easter lilies blooming in time for the Easter market, Poinsettias blooming in time for Christmas, and so on. All that is required to trigger initiation of the bloom cycle is to mimic the behavior of their native environment just prior to their natural bloom time. If we have figured out what the triggers or cues are, we can merely mimic those and achieve our ends. It can be quite specific: day or night length, soil or air temperature, temperature differential between day and night, a period of dryness of a specific length... each organism has its own triggers based on the encoded information in its models. All "instinctive" behavior of living organisms is based on the activity of such internal predictive models, generated from encoded information within their own systemic organization. To observe and learn about the annual migration of Monarch butterflies in North America gives us enough evidence to put us in awe of just how detailed the encoded information can be and how powerful is the guiding action of these internal models on the behavior patterns of all living things.

There are stark dangers embodied in this situation, however, which will become clear as you read this book. The dangers stem from the fact that many of the encoded models (and/or the information from which they are constructed) are either not able to be changed within a single organism's life time or else they change too slowly to be able to avoid disaster in a rapidly changing world. There is no way to know, from within a model, that the system it was encoded from has changed radically. The model will keep on making predictions using wrong information – and the organism will still be guided, partly or entirely, by those predictions. If the predictions are inappropriate, the behavior will similarly be inappropriate – perhaps to the point of mismatches that prove lethal to the organism. Because organism species within an ecosystem are so interlinked in their requirements and dependencies, the death of significant numbers of one species can initiate further rapid changes in the behavior of the local environment, which can ultimately cause rapidly escalating cascades of extinctions.

This is the Achilles heel, the innate vulnerability, of all anticipatory systems. With human-induced changes to the composition of Earth's atmosphere happening at an unprecedented pace over the past two hundred years, and the further unknown changes which are likely to be caused by them, we would do well to pay very careful attention to the warning that is inherent in these facts. Any model-based guidance system will only be as good as the encoded information it uses. If a model is constructed using inaccurate information, its predictions will be unreliable – and this is as true in science as it is in the guided behavior patterns of organisms.

Indeed, because human beings are living organisms, we are also anticipatory systems. The lessons we can learn and apply from this will impact everything. Something as ordinary and commonplace as *how we construct our food pyramid* should be based on what our bodies have encoded as “food”. My hope (my prediction) is that the ramifications of these ideas can expand the paradigm of science itself. The effects of doing so would benefit everything from medical science to psychology, social science, political science, economics – in fact: anything that involves human physiology, human thought and learning, and human interactions with each other or with the biosphere.

The nature of the human mind, in particular, has so far eluded most of the attempts we have made in science to understand it. We seek to comprehend both the nature of our own consciously aware mind and its origins – how it came into being. The final ground-breaking aspect of this book is that it realizes, within the fundamental theory being developed here, that the similarity between life and mind is simply that both are anticipatory systems. The peculiar, anticipatory nature of the mind, at the behavioral and physiological level, was described philosophically a couple thousand years ago (for example, in Buddhist teachings like the Satipathanna Sutta) but it has never been explainable via science, until now. Anticipatory Systems Theory elucidates how it can be that both body and mind run on the same principles of model-based guidance and control.

In that light, it becomes clear that the only reason the human mind can anticipate is because life was already *that way*. Thus, the human mind is merely an evolutionary concentration of the same information-sifting, encoding, and model-

building capacities of living system organization. It is a model-building tool that is capable of error-checking and re-encoding faulty models – but in real time versus evolutionary time. The accuracy and speed of an organism’s ability to model and predict would naturally be something that selection pressures could act on. The boon to survival that human intelligence and imagination represents – allowing us to work around all manner of physical limitations in our environments and ourselves – certainly correlates with how overpopulated humanity has become.

However, the recognition in recent years of the need for human societies to be sustainable in order for us to maintain our own health and well-being, over time, brings with it an awareness that there is an acute and urgent need for scientific answers that we can rely on pertaining to biological questions, problems, and issues. When time is short, trial and error is hardly the most efficient or productive mode for sorting out our choices. Because our own welfare is inextricably bound up with the welfare of the biosphere, humanity will need to consider a much larger set of values for optimality than we have ever needed to use in the past. This book will be essential for helping humanity expand the scientific paradigm in such a way that it can finally be trusted to answer biological questions *accurately* and give us scientific models and model predictions that can *reliably help us in choosing the most optimal pathways towards a healthy and sustainable future*.

It is for all these reasons and more that I have worked to get this book republished in the form of an expanded Second Edition. An entire new area of science has already begun to spring up around this work, but without access to the theoretical underpinnings to guide its growth, I fear that it will be prone to develop improperly. I also wanted to include some of the new science, recruiting scientists I know personally who are developing it; allowing them to describe what they are doing and show the applicability of it. The true test of any theory is to put it into practice and see if it holds – see if it generates results and check that the results are beneficial. I think the evidence is conclusive. I leave it to the reader to decide whether I have my own models properly encoded, or not.

If it is true that knowledge is power, then this book is powerful, indeed. Use it wisely, and well.

Judith Rosen

[Note to Readers: Do not be intimidated by the mathematical notation in this book! In discussions with my father on this subject, he said that the mathematics represent *additional illustration of ideas already described in prose*. It was his form of “bullet-proofing” as well as whatever value could be made available to readers from absorbing the same ideas in a different way. I specifically asked him whether one needed to understand the math to fully comprehend the work and he said, “No.” Therefore, if advanced math is something you have not been trained for, concentrate on the prose and ignore the mathematical illustrations. You have Robert Rosen’s own assurances that you will not be missing any essential information by doing so.]

Anticipatory Systems  
Philosophical, Mathematical, and Methodological  
Foundations

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2012, LX, 472 p., Hardcover

ISBN: 978-1-4614-1268-7