

Preface

The book introduces a radically new way of thinking about information and the central role it plays in living systems. It opens up new avenues for exploring how cells and organisms change and adapt, since the ability to detect and respond to meaningful information is the key that enables them to decipher their genetic heritage, regulate their internal milieu, and navigate safely through their surroundings. Information is a function of the way that matter and energy are organized and arranged in space and time, a property of their *form* rather than their substance. Form refers to the shape and appearance of material objects, like the contour of a palm tree or the outline of the Eiffel Tower. Form and substance are inseparable, however, since it is impossible to conceive of form that has no substance, or substance that has no form. But patterns of matter and energy only convey *meaning* to someone or something that can detect and decipher them—as they otherwise have no effect. Each cell type and each species is endowed with receptors that enable them to perceive a subset of such patterns. The particular patterns they can detect have been shaped by natural selection to enable them to function effectively within their particular ecosystems. Biological detection and response systems range from the chemical configurations that govern genes and cell life to the relatively simple tropisms that guide single-cell organisms, the rudimentary nervous systems of invertebrates, and the complex neuronal structures of mammals and primates.

Meaningful information is defined here as a pattern of matter or energy that is detected by an animate or manufactured receptor that then triggers a change in the detecting entity's behavior, functioning, or structure. The detecting entity can either be a macromolecule, a cell, an organism, a plant, an animal, or a fabricated device; and the change it generates may be either a behavioral one, like fight or flight, a physiological one, like salivating or sweating, or a structural one, like reconfiguring the neural connections involved in learning and memory. Detected patterns of matter or energy that have no effect on a recipient are considered to be meaningless as far as that particular individual is concerned at that particular time. This concept provides a way of understanding how living entities interact with the environment and with each other, separate from the way they interact and respond to physical stimuli. The book thus touches on topics that range from cellular signaling to

conscious decision-making, from category formation to goal-directed behavior, from genetic and emotional information to analog and digital forms of representation, and from information theory and neural circuits to maladaptive behavior and the mind–brain interface.

Meaningful information and free energy are both properties of organized matter that function as causal agents, although they do so through different mechanisms. The effects caused by information differ from those caused by energy in that they are primarily determined by the recipient, rather than the initiating entity. The effects that detected information elicits are activated by energy supplied by the recipient and determined by its molecular or neural connections, rather than by the initiating stimulus, so that neither the magnitude nor the type of the response has any relation to the event that triggers it. This is why the way a cell or organism (or device) responds to information cannot be predicted on a purely mechanical basis, why the amount of information being conveyed is independent of the amount of energy used to convey it, and why information-caused events do not follow Newton's laws. This is also why the behavior of living entities cannot be explained entirely in the mechanistic terms used to understand the physical world—and why biology cannot simply be reduced to physics and chemistry.

Both our genetic and experiential heritages are basically informational sets that tell our cells what to do, our organs how to function, and ourselves how, when, where, and why to act. All living creatures exhibit goal-directed behavior, from the bacteria that seek out food sources to the birds that fly south for the winter to the stockbrokers who trade on Wall Street. The inability of physical explanations to account for this type of behavior has been a major obstacle to understanding the mind as a part of the natural world—for how can future outcomes that have not yet happened cause individuals to behave the way they do? It is no wonder that people thought that some sort of mystical process must be involved in causing this, some as yet unidentified vital force or spirit. They were right about there being another process, but not about what it was. We no longer have to equate nonmechanical causation with magic and superstition, since the detection of meaningful information can initiate changes in biological and behavioral systems that are not explainable on a purely physical basis. The vital spirit that animates living things is not some ethereal force beyond our grasp, but simply is the ability of cells and organisms to detect and respond to meaningful information.

The book is thus aimed at a broad audience, primarily in the fields of general and evolutionary biology, cognitive psychology, neuroscience, and philosophy. It explores the larger picture that links these disciplines together, rather than the details that separate them from each other. Although anchored in the discoveries and insights of the particular disciplines, this wider perspective weaves these together to provide new ways of understanding what information is and what it does. However, because this way of thinking about information does not fit neatly into any one of these disciplines, it sails at times against some of their conventional views. Knowledge and understanding advance both through exploring the details of how entities function and by linking these back together to explain why they do. This book follows this latter tradition and is, as a consequence, based more on research in the library than in the laboratory. The many authors on whose ideas and efforts it has been built are gratefully acknowledged in the text and listed in the references.



<http://www.springer.com/978-1-4614-0157-5>

Meaningful Information

The Bridge Between Biology, Brain, and Behavior

Reading, A.

2011, XIV, 158 p. 1 illus., Softcover

ISBN: 978-1-4614-0157-5