



FOUNDATIONS OF MINDFUL KNOWLEDGE

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Foreword

There are books that answer questions, and there are books that teach us how to ask better ones. This book belongs to the second kind.

We live in a world transformed by information, yet we rarely pause to ask what information is. We store it, transmit it, protect it, monetize it, and increasingly build our institutions and technologies around it. We speak of information as if its meaning were self-evident. But as this book makes clear, familiarity is not understanding. In fact, the very ubiquity of the word has allowed a deep conceptual uncertainty to remain hidden in plain sight. That is why this work matters.

Rao Mikkilineni invites the reader to return to first principles, not as an academic exercise, but as a necessary act of intellectual repair. The questions at the heart of this book are foundational: What is information? How is it related to knowledge? What kinds of structures and levels of reality must we recognize if we are to understand cognition and intelligence without confusion? These are not narrow questions. They stand beneath many of the great debates of our time, from the nature of mind to the future of intelligent machines.

What is especially valuable about this book is its refusal to accept easy reductions. Modern life has trained us to equate information with data, signals, messages, or stored content. Those equations are useful in their proper settings, but they can also become traps. We begin to confuse transmission with meaning, storage with knowledge, and processing with intelligence. This book resists that flattening. It asks the reader to recover a broader and more disciplined understanding, one capable of supporting deeper thought across science, philosophy, and technology.

This is not an argument against rigor. On the contrary, it is an argument for a richer rigor. The author does not reject the achievements of formal theory, computation, or engineering. He asks us instead to place them within a larger framework, one that can do justice to living systems, cognition, and the layered structure of reality. That ambition gives the book both its scope and its seriousness.

I have long believed that the most important ideas are often those that connect fields that have grown too comfortable in separation. Innovation does not come only from solving known problems more efficiently. It also comes from finding the right representation of a problem, one that reveals hidden connections and makes a new path visible. This book does precisely that. It offers information not as a narrow technical category, but as a missing foundation for understanding knowledge, mind, and intelligence in a more integrated way.

Readers will find in these pages both conceptual challenge and intellectual reward. They will also find a rare willingness to think across boundaries: between philosophy and computer science, between biology and cognition, between formal systems and lived understanding. In an era that often prizes speed over reflection, this book offers something more enduring: a framework. That is why I welcome this work. It reminds us that progress in science and technology depends not only on better tools, but on better foundations. And it reminds us, too, that some of the most practical questions begin as philosophical ones.

If the twenty-first century is to be shaped by information, then we will need more than systems that process it. We will need ways of thinking that understand what information is, what it is not, and what becomes possible when we finally treat it with the depth it deserves. This book is an important step in that direction.

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Introduction

Why Information Became the Missing Foundation

We live in an age that treats information as both obvious and supreme.

It is the word behind our machines, our markets, our sciences, and increasingly our metaphors for mind itself. We speak of information systems, information networks, information overload, information processing, information economies, and information warfare. We store it, transmit it, secure it, monetize it, and drown in it. We speak as if information were the basic substance of modern life.

And yet the more confidently we invoke the word, the less certain we seem to be about what it means.

That uncertainty is easy to miss because the term feels so familiar. It belongs equally, or so it seems, to a spreadsheet, a genome, a courtroom document, a map, a traffic signal, a memory, a pulse reading, a theorem, a warning, a sentence, or a stream of binary code. The breadth of its use creates an illusion of clarity. We assume that because we can point to so many examples, we understand the concept they share.

But examples are not explanations. A civilization may organize itself around a word without ever fully examining the ground on which that word stands.

This book begins from the claim that information has become the missing foundation of modern thought. It is missing not because no one has studied it, but because it is so often treated as settled when it is not. The modern world has become expert in handling information while remaining surprisingly unsure what information is. We have learned how to encode it, compress it, transmit it, store it, and process it. But the conceptual foundation beneath those achievements remains thinner than their success encourages us to admit. That thinness matters.

It matters because once information is treated too casually, everything built upon it begins to inherit the confusion. Knowledge is reduced to stored content. Meaning is confused with transmission. Mind is modeled as computation without asking what computation is operating on. Intelligence is flattened into output, prediction, or processing. The vocabulary changes from discipline to discipline, but the underlying habit is the same: we proceed as though information were obvious, and then wonder why the higher questions remain elusive.

This is one reason so many important debates become strangely repetitive. What is knowledge? What is meaning? What is understanding? Is the brain

a computer? Are intelligent machines possible, and if so in what sense? These arguments often reach impasse not because they lack ingenuity, but because they begin too late. They start with cognition, machine, language, or consciousness, when they should have begun with the more basic question of information itself.

The purpose of this book is not to turn information into a slogan or an idol. It is to restore precision where familiarity has bred haste.

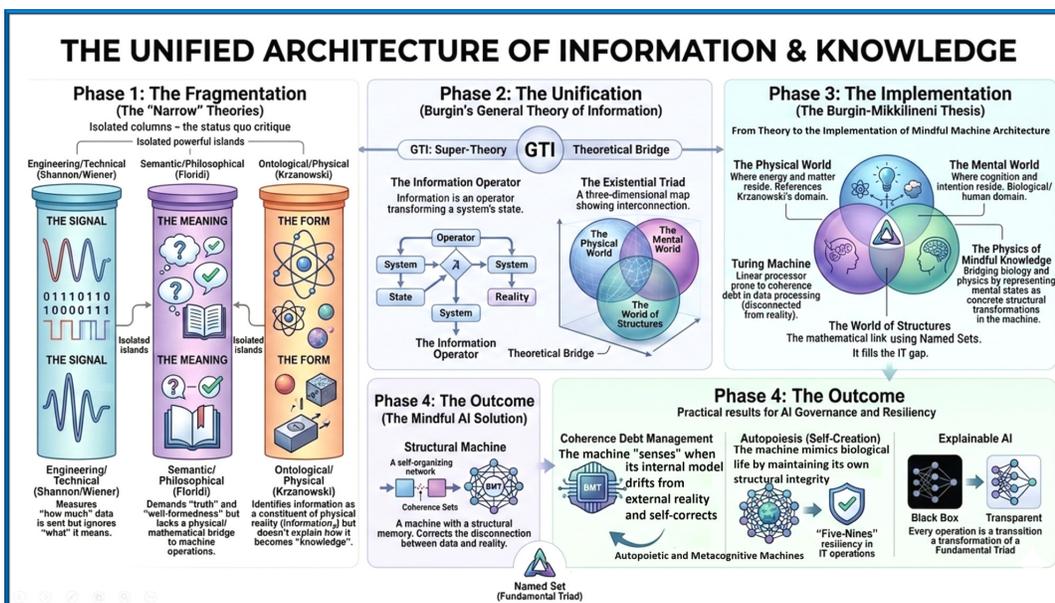
That requires patience. It requires resisting the temptation to define information too quickly by one of its most visible forms: data, signal, message, stored content, transmitted content, coded content. All of these matter. None is enough. If this book succeeds, the reader will come to see that information is not merely a technical term borrowed from communication engineering, nor a vague metaphor stretched across too many fields. It is a foundational category whose proper clarification changes how we think about knowledge, meaning, life, cognition, and intelligence.

The path of the book moves outward in a deliberate sequence.

It begins by asking what information is, and why the most familiar answers prove too narrow. It then asks how information becomes meaningful, how it differs from knowledge, and what kinds of structure and layered reality are required for those distinctions to make sense. From there, it turns toward living systems, cognition, and intelligence, not to collapse them into information, but to show that none can be understood well without it.

The argument, then, is cumulative. It moves from concept to consequence:

information -> meaning -> knowledge -> cognition -> intelligence



This movement is the hidden spine of the book.

The reader should also know what this book is not. It is not a technical manual. It is not a defense of reductionism in a new vocabulary. It is not a manifesto about artificial intelligence, though its conclusions will matter there. And it is not an attempt to force every domain into one abstract formula. Its aim is more careful and, I hope, more durable: to establish a foundation broad enough for the real complexity of the phenomena built upon it.

We live in an age saturated with information and starved for first principles. That is why this inquiry matters now.

The chapters that follow begin with the most basic question and one of the most deceptively difficult: What is information?

Chapter 1

What Is Information?

1. Toward a Purposeful Definition

Few words dominate modern life more thoroughly than information. We live in economies that prize it, in institutions that manage it, in technologies that process it, and in cultures that drown in it. We speak of information overload, information access, information security, information systems, information flows, and information economies. The word is now so common that it seems almost transparent. Yet that very familiarity has thinned its meaning and purpose.

And that transparency is deceptive.

We use the same word for a weather warning on a phone, a spreadsheet of quarterly sales, a DNA sequence, a whispered sentence, a traffic signal, a court ruling, a map, a pulse reading, a memory, and a page of legal text. It would be easy to assume that the differences do not matter, that “information” is just a practical umbrella under which many unrelated things happen to gather. But the opposite may be true. The sheer range of its use may indicate not vagueness, but depth.

Still, depth is not clarity. The more often a word is invoked, the easier it becomes to mistake familiarity for understanding. Information is one of those concepts that seems obvious until the moment one asks what kind of thing it is. Is it a substance? A relation? A message? A pattern? A signal? A record? A difference? A change? Something objective in the world, or something dependent on an observer? A technical artifact of communication theory, or a foundational category reaching into life, mind, and knowledge?

These are not merely academic questions. They underpin some of the most important debates of modern thought. What is knowledge? How does meaning arise? What does a mind do? What makes intelligence possible? Why do some systems merely process symbols while others seem to understand? Such questions become confused very quickly if information is treated carelessly.

This chapter begins, then, with a deceptively simple question: What is information? The goal is not to produce a slogan in place of a concept. It is to show why the familiar answers, useful as they are, fail to cover the full field. By the end of the chapter, the reader should no longer be satisfied with the easy substitutions that modern culture offers. Information will still be difficult, but its difficulty will have the dignity of a real problem.

2. The Comfort of Familiar Definitions

When asked what information is, most of us do not define it directly. We point instead to one of its most visible forms. We say it is data. Or a signal. Or a message. Or perhaps simply content stored somewhere, waiting to be retrieved. These answers feel satisfactory because they are not wholly wrong. They arise from the practical situations in which information most often meets us: on screens, in files, through alerts, inside documents, across networks.

That is the comfort of familiar definitions. They are close at hand. They succeed within limited domains. They offer the relief of concreteness. Instead of wrestling with a foundational concept, we point to its most familiar carriers and conclude that the matter has been settled.

But what is close at hand is not always what is most fundamental.

The problem with these ordinary substitutes is not that they should be discarded. Data, signals, and messages are indispensable categories. The problem is that each is tempted into doing more philosophical work than it can bear. Each describes a way information appears. None adequately defines what information is across the full range of cases in which the term matters.

This is why the chapter has tested them in turn. Data capture record but not significance. Signals capture transport but not the full ontology of what is transported. Messages capture communication but presuppose the very structures of code, relation, and interpretation they seem to define. The familiar terms remain useful. They simply need to be placed back into perspective.

To understand information well, then, is not to abandon these categories. It is to see them as partial expressions of a broader concept, one that cannot be confined to any single medium, event, or setting. The rest of this book will work outward from that broader concept, asking how information becomes meaningful, how it differs from knowledge, how it participates in cognition, and why all of this matters for intelligence itself.

But first the narrower inheritance must be understood on its own terms. That is the work to which we now turn.

3. Data Are Not Yet Information

The most common reduction of information is also the bluntest: information is data. The equation feels natural because the modern world is drenched in data. Databases, dashboards, spreadsheets, logs, surveys, files, and measurements all seem to offer us information in tangible form. If one asks where information lives, data appear to provide the obvious answer.

But the obvious answer stumbles almost at once. A page filled with random digits is data, but it may tell us nothing. A corrupted file contains recorded bits, yet may fail to inform anyone of anything. A database can hold duplicate records by the millions without adding a single insight. A sensor may produce noise instead of usable measurement. An archive may preserve traces that no one can decode. In each case, data are present. Information, in any richer sense, is uncertain, absent, or only potential.

This suggests the first important distinction. Data are records, marks, measurements, traces, or symbols. They are inscriptions of some kind, stored or displayable content. Information may appear in or through such records, but it is not identical to their mere existence. To confuse the two is to treat raw presence as if it were already significance.

That confusion is understandable. Data feel concrete. They can be counted, moved, copied, stored, sorted, and visualized. They are easy to point to. Information, by contrast, is harder to isolate. It seems less like a thing and more like a role something plays within a relation. It is therefore tempting to collapse the slippery concept into the tangible one. But that move purchases simplicity at the cost of accuracy.

A simple example makes the point. Imagine a notebook filled with symbols from a script you do not know. It is unquestionably data: visible marks, stable inscriptions, reproducible forms. But whether it is information for you depends on more than its presence. If you cannot distinguish the symbols, decode the syntax, or relate them to anything else, then the notebook remains data without becoming informative in any meaningful sense. Its informational status is not exhausted by the marks themselves.

Or imagine a table of numbers torn from any context. Without units, labels, provenance, or comparison, the numbers may remain inert. They might be temperatures, stock prices, ages, distances, or merely arbitrary entries. Their being data does not by itself determine their informativeness. The transition from data to information requires relation, structure, or use. Something must connect the marks to a difference that matters.



This does not mean that data are unimportant. Quite the opposite. Data are often the material through which information becomes accessible. They are one of its most common vehicles. But the vehicle is not the journey. We do not understand music by describing the grooves on a vinyl record, though without grooves the music would not be there in that form. In much the same way, data are often what information is made of, but not what information is.

The distinction matters because once information is reduced to data, whole categories begin to flatten. Knowledge becomes a larger pile of stored content. Learning becomes accumulation. Memory becomes archive. Understanding becomes retrieval. These reductions will haunt later discussions unless they are stopped early. The world of information is not simply the world of more recorded traces. It is the world of structured differences that become significant within larger patterns of relation and transformation.

Data, then, are not yet information. They are one of the forms through which information may be preserved, displayed, or processed. But a record, however precise, does not become informative merely by existing. It becomes informative within a structure that makes some difference legible, usable, or consequential.

If data are too passive to define information fully, the next candidate seems more promising because it introduces movement.

4. Signals Carry, But Do Not Exhaust, Information

Signals bring us closer to the heart of the matter because they introduce relation and effect. A signal is not just a stored mark. It is an event or pattern that indicates, alerts, triggers, conveys, or points beyond itself. Smoke signals fire. A bell signals danger. A heartbeat monitor signals change in a patient's condition. A phone notification signals an arrival. In each case, something is made known through an occurrence that matters.

This makes signal-based definitions of information deeply attractive. They replace inert record with active indication. Information begins to seem less like content lying around in a warehouse and more like something that travels, reaches, and alters response. Much of modern communication theory gains its power from precisely this shift. The question becomes not merely what is there, but what can be transmitted, with what reliability, across what channel, under what constraints.

That achievement is genuine and enormous. Once information is treated in terms of signals, we can analyze communication with rigor. Noise, bandwidth, encoding, redundancy, and fidelity become tractable problems. Entire infrastructures of modern life, from telecommunications to computing networks, depend on this conceptual triumph. Any broad theory of information that ignored it would be unserious.

And yet the success of signal theory can tempt us into a larger claim than it deserves. A signal explains conveyance. It does not explain the entire nature of what is conveyed.

A smoke plume may signal fire, but the information is not identical to the smoke. The same smoke could be misread, unnoticed, or artificially produced. A radio wave may carry a broadcast, but the broadcast is not exhausted by the wave's physical behavior. A notification ping may alert a user, but what is informative about it lies partly in a larger field of expectation, interpretation, and consequence. The signal is an event of transmission or indication. Information has a wider life than transmission alone.

This becomes clearer when we consider forms of information that are not primarily signal-like. A map sitting folded in a drawer is not actively signaling anything, yet it still contains organized differences that can guide action. A genome is not best understood as a message sent in the ordinary communicative sense, yet it informs development. A legal constitution may remain dormant for long stretches, yet continue to structure a field of possible action. A memory may shape present judgment without being transmitted as a signal from one place to another. In all these cases, information is bound up with structure, preservation, and possible transformation, not just with an event of conveyance.

Signal theory, then, captures something essential but not comprehensive. It teaches us that information often matters because it makes a difference across a relation. But it remains too transport-centered to serve as the master definition. Information may be carried by signals without being reducible to them. A theory of transmission is not yet a theory of information.

This distinction is easy to miss because the modern world privileges systems of communication. We are surrounded by channels, screens, alerts, and streams. Information seems always to be arriving from somewhere. But this cultural habit can obscure the deeper fact that information can also persist, structure, constrain, and orient without being actively sent. The dynamics of communication are real. They are not the whole ontology.

Once this is seen, another candidate presents itself. Perhaps information is best understood, not as raw data or transmitted signal, but as message. That view moves closer to meaning, but it introduces a different kind of limitation.

5. Messages Presume More Than They Explain

The concept of message feels richer than either data or signal because it already carries a world within it. A message suggests not only form and movement, but intention, direction, code, sender, receiver, and possible interpretation. A letter, an email, a warning sign, a command, a declaration, a promise: all of these are messages. They do not merely exist or travel. They say something to someone under some condition.



For that reason, message often seems like the most satisfying everyday definition of information. It appears to gather what data leave inert and what signals leave too mechanical. Messages are already structured, contextual, and humanly legible. If information is what is communicated, what could be more natural than to say that information is message?

The answer is that message presupposes more than it explains.

A message is not a primitive notion. It depends on a host of prior conditions: some code or convention, some relation between source and recipient, some medium, some context, some possibility of uptake or interpretation. An unread email is still a message, but only because it belongs to such a structured world. A letter in a bottle remains a message even before it is opened because it already presumes language, inscription, direction, and communicative form. A legal notice in an unknown language is a message to one reader and inert marks to another. In every case, the category of message already leans on a wider informational landscape.

This means that message cannot serve as the most general definition. It is one highly developed form of information, especially within human and symbolic life. But many informational realities are not well described as messages at all. A fossil layer is informative without being a message. A scar is informative without being intentionally communicated. A memory trace is informative without being addressed from sender to receiver. A genetic sequence may be spoken of metaphorically as a message, but the metaphor begins to strain if taken too literally. These cases show that communication is an important special case, not the universal mold.

The temptation to define information as message also narrows the concept around human-like exchange. It privileges linguistic and symbolic forms that are indeed central to culture, law, teaching, politics, and everyday life. But information exceeds those forms. It also belongs to bodily processes, developmental processes, material traces, internal states, and structural relations that are not neatly captured by the grammar of sending and receiving.

This does not make the concept of message trivial. On the contrary, messages are among the highest and most elaborate forms information takes. They are indispensable to social life. But precisely because they are so rich, they cannot be the starting point. To define information by message is to define the wider field by one of its most familiar and sophisticated instances.

Once that is clear, the pattern across the three reductions becomes easier to see. Data isolate record. Signals isolate transmission. Messages isolate communication. Each points to something real. Each leaves too much out. A broader concept is needed, one capable of explaining why all three count as informational without allowing any one of them to seize the throne.

And if such a broader concept matters, it matters because the consequences of getting the definition wrong are not confined to terminology.

6. Toward a Broader Concept

The familiar definitions of information fail not because they are false, but because they are partial. Each captures one visible aspect of a larger reality and then mistakes that aspect for the whole. Data emphasize record. Signals emphasize transmission. Messages emphasize communication. All three matter. None is enough.

What they leave out, above all, is structure.

A page of numbers, an alarm bell, and a written sentence may all count as information, but they do not do so in the same way. What makes them informational is not merely that they exist, or that they move, or that they are sent. It is that they participate in an organized difference within some larger relation. They alter what can be known, inferred, expected, decided, or done. They matter not as isolated objects, but as structured elements within a field of possible transformation.

That phrase, possible transformation, brings us closer to what is at stake. Information is not merely a thing stored in a container or moving through a channel. It is bound up with the ways in which systems can be changed, organized, oriented, or made intelligible. A map changes a traveler's possible path. A legal ruling changes the space of permitted action. A genetic sequence shapes development. A memory alters present judgment. In each case, information is not exhausted by marks on paper, pulses in a wire, or words in a sentence. It lies in the structured differences that make some transformation possible and others not.

This broader view immediately explains why narrow definitions keep feeling unsatisfying. They are carrier-bound. They attach the concept of information too closely to the medium in which it appears. Data are treated as information because information is often recorded. Signals are treated as information because information is often conveyed. Messages are treated as information because information is often communicated. But the carrier is not the concept. The envelope is not the letter, and the letter is not the meaning, and the meaning is not yet the truth. Once these layers are separated, the concept begins to breathe.

To say that information is bound up with structure and transformation is not to make it vague. It is to notice that the concept must be broad enough to travel across domains without collapsing into nonsense. Information appears in physical systems, in living systems, in social systems, in legal systems, in symbolic systems, and in minds. A concept narrow enough to fit only one



of these will distort the others. A useful theory must explain why information can appear as record, signal, symbol, memory, pattern, instruction, or relation without being identical to any one of them.

That is why a richer concept is needed. Information belongs to the organized differences by which systems relate, preserve distinctions, register change, and make transformation possible. It is visible in communication, but not confined to communication. It appears in symbols, but is not reducible to symbols. It may be stored, transmitted, interpreted, embodied, or acted upon. None of these is the essence. Each is a mode.

Seen this way, information begins to look less like a specialized technical term and more like a foundational category. The point is not to glorify the word. It is to use it carefully enough that knowledge, meaning, cognition, and intelligence can later be described without confusion. If information is defined too narrowly at the beginning, everything built upon it shrinks. If it is defined broadly but carelessly, everything dissolves into metaphor. The task is to avoid both errors.

A better starting point, then, is this: information concerns structured differences that can make a difference within or across systems. That is still only a first approximation. It will need refinement. But it is enough to show why data, signals, and messages are not competing definitions so much as partial windows into a larger reality.

And once that larger reality begins to come into view, the narrower candidates can be reconsidered more precisely.

7. Why the Definition Changes Everything

At first glance, the dispute over the meaning of information may seem merely verbal. Why not let engineers use one definition, biologists another, philosophers a third, and ordinary language a dozen more? Why insist on broader conceptual discipline?

Because definitions do not stay in dictionaries. They migrate into theories. And once there, they shape what whole fields are able to see.

If information is reduced to data, knowledge begins to look like storage. The richer problems of understanding, retention, judgment, and use are flattened into questions of accumulation and retrieval. Learning becomes the gathering of more records. Memory becomes archive. The distinction between a library and a mind begins to blur in precisely the wrong way.

If information is reduced to signal, meaning begins to look like transmission success. We start to treat communication as though its central mystery were reliable conveyance rather than significance, interpretation, and truth. What

matters becomes whether something got through, not what it became in the process of being received, understood, or acted upon. Important as transport is, it cannot carry the full burden of meaning.

If information is reduced to message, then the broader informational realities of living systems, internal states, and noncommunicative structures begin to disappear. We over-humanize the concept. We privilege sender-receiver scenarios and forget that much of the world's information is not a letter addressed to anyone. It is embodied in form, relation, development, regulation, and history.

These distortions accumulate. Biology becomes harder to understand because regulation, memory, and development are forced into too narrow a conceptual mold. Cognition becomes harder to understand because thought is treated as signal handling or symbol exchange rather than organized transformation. Intelligence becomes harder to understand because output is mistaken for understanding, and processing for knowledge.

The practical consequences are serious. Once information is defined too narrowly, the sciences built upon it inherit a conceptual handicap. We begin to confuse storage with knowledge, transport with meaning, and processing with intelligence. We also make ourselves strangely vulnerable to technological illusion. Systems that manipulate vast quantities of data or generate persuasive messages can appear more understanding than they are, simply because our underlying concepts are too shallow to distinguish performance from deeper organization.

For that reason, the work of this chapter is not merely preparatory. It is foundational. A broader concept of information does not solve every later problem, but without it later problems are posed badly from the start. What counts as knowledge, how meaning arises, how cognition works, what intelligence requires, all these questions depend on what we think information is.

That is why the chapter has proceeded by subtraction. Before a richer account can be built, the familiar reductions must be placed in their proper scale. They are not false gods, only provincial ones.

But before that argument is gathered, it is worth returning to where the chapter began: the strange familiarity of the word itself.

8. Conclusion

We began with a word so common it seemed almost too familiar to question. By the end of this chapter, that familiarity should have become less innocent. Information appears in data, travels by signals, and often takes the form of messages. But it is not exhausted by any of them.



Data are too inert to define it. Signals are too centered on transport. Messages are too dependent on a communicative setting they cannot themselves explain. Each capture one face of information while missing the larger reality in which that face becomes possible.

The broader concept proposed here is still provisional, but it is enough to orient the rest of the book. Information belongs to the structured differences by which systems can be changed, organized, related, and made intelligible. It is visible in records, active in transmission, rich in communication, but not confined to any one of these modes. This wider view is necessary if we are to think clearly about knowledge, life, cognition, and intelligence without flattening them into the most convenient language of our age.

The task of the next chapter is to understand why narrower models became so influential. They did not triumph by accident. They illuminated important parts of the field with extraordinary precision. But their success also helped train the modern world to think of information mainly in terms of transmission, encoding, and uncertainty.

To see both the power and the limits of that inheritance, we now have to look more closely at the theories that shaped it.

Chapter 2

Beyond Data, Signal, and Message

1. Opening

Few intellectual moves have been more consequential than the modern decision to treat information as something measurable, transmissible, and encodable. That decision helped build telecommunications, computing, digital storage, networking, and much of the technical world we now inhabit without noticing. It also did something quieter and more philosophical. It trained us to think that we knew what information was.

The success of the narrow theories made this almost inevitable. When a concept helps solve problems at scale, it acquires authority far beyond its original setting. What began as a disciplined way of handling uncertainty and transmission came to shape how modern culture imagines communication, data, knowledge, and even thought itself. Information started to seem self-evidently like something that moves through channels, is stored in systems, and can be optimized by code.

And why not? Those theories worked. They worked so well that skepticism would have seemed churlish. They brought clarity where there had been vagueness. They made invisible processes measurable. They turned fragile communication into robust engineering. They deserved their prestige.

But success creates its own form of blindness. The stronger a model becomes within its proper scope, the easier it is to forget that it has a scope. The clearer its abstractions, the more likely they are to masquerade as reality itself. A narrow idea can conquer the modern world not by being false, but by being brilliantly useful.

This chapter asks what happened when that occurred. What did the narrow theories of information genuinely achieve? Why were they so compelling? And what did their very success encourage us to overlook?



These are not hostile questions. They are questions of scale. The aim is not to diminish the classical theories, but to place them where they belong: indispensable within their domain, incomplete beyond it. Only then can the rest of the book proceed without confusion.

2. Why Narrow Theories Triumphed

The narrow theories triumphed because they offered something modernity craved: clarity. Earlier talk about information had often been diffuse, intuitive, and context-dependent. The newer theories transformed a slippery idea into something one could measure, calculate, optimize, and build with. In an age increasingly organized by engineering, that was irresistible.

The appeal was not merely technical. Precision creates authority. A concept that can be quantified and operationalized quickly acquires prestige, especially when it delivers results. Once information could be handled with mathematical discipline, it ceased to look like a vague philosophical notion and began to appear as a robust scientific one. That shift changed not only engineering but imagination. It encouraged people to think that the essence of information had finally been captured.

This was not irrational. The modern world genuinely needed models of communication that could survive scale, noise, and complexity. Networks had to function. Messages had to arrive. Signals had to be protected, compressed, and reconstructed. The narrow theories answered these needs with astonishing effectiveness. Their power was practical before it was philosophical.

But practical success rarely stays in one domain. It radiates outward. Concepts that work in engineering begin to shape metaphors in psychology, biology, management, and common sense. The cleaner the model, the easier it is to carry into new terrains. And the more successful the model, the less often anyone pauses to ask whether the new terrain really fits it.

That is why the triumph of the narrow theories was double-edged. They deserved to win in their own field. The problem arose only when a domain-specific victory became a wider worldview. Information came to be imagined primarily as what can be measured, sent, stored, encoded, or recovered. The success of the model encouraged people to forget how much had been deliberately left outside it.

In that sense, the narrow theories were not merely scientific achievements. They were cultural events. They taught the modern world to associate intelligence with processing, communication with transmission, knowledge with storage, and reality with what can be formalized. Much of the work of this book consists in recovering what those associations leave behind.

The triumph, then, was real. So was the narrowing. Both facts must be held together if we are to move toward a concept of information broad enough for the tasks ahead.

3. Information as Uncertainty Reduction

One of the most powerful simplifications in modern thought was to define information in terms of uncertainty. This was not merely a clever technical decision. It was a conceptual revolution. It gave shape to a field that had often been too loose, too intuitive, and too dependent on ordinary language to sustain a fully rigorous treatment.

The intuition behind the move is easy to grasp. If I already know with complete certainty what will happen next, then whatever arrives carries little new information in the formal sense. If the sun rises tomorrow, that event may matter greatly to life, but it does not surprise. By contrast, if the outcome of a fair coin toss is genuinely uncertain, learning whether it lands heads or tails reduces uncertainty. In this framework, what counts as information is not the richness of meaning but the formal change in what was not known in advance.

This shift achieved something extraordinary. It detached information from subjective vagueness and placed it inside a formal structure. Information became measurable. Events could be compared by how much uncertainty they resolved. More improbable occurrences carried more formal informational weight than highly predictable ones. What mattered was not whether the content was wise, beautiful, or true, but whether it altered the space of possibilities in a quantifiable way.

That elegance explains the theory's enduring force. It answered a question science could work with. Instead of asking what information means in all the varied richness of language, cognition, and life, it asked: how much uncertainty has been reduced? The answer could be formalized. And once formalized, it could be used.

This is why the concept spread so successfully. A weather report may have high significance to a farmer, but within this framework its informational quantity depends on how uncertain the event was beforehand. A highly unexpected report counts differently from a fully anticipated one. Likewise, a random string of symbols may carry more formal information than a deeply meaningful but predictable phrase. That feels counterintuitive only if one forgets the narrow but precise question the theory is asking.

And that question is not foolish. It is brilliant. It allows one to measure information without first settling disputes about meaning, truth, or interpretation. It makes rigorous analysis possible in domains where such disputes would otherwise paralyze formal progress. In this sense, the theory's refusal to speak about



semantics is not a weakness but a source of strength. Surprise is measurable. Meaning is not so easily disciplined.

Yet that very strength generates the later difficulty. A highly unexpected message may reduce uncertainty without producing understanding. A sequence of random symbols may contain great formal information while conveying almost nothing of human significance. An unexpected but trivial notification may carry more informational novelty than a familiar but morally decisive truth. The framework is not wrong in any of these cases. It is simply not speaking about the same dimension of human concern.

This is where confusion begins. Once uncertainty reduction becomes identified with information as such, the broader concept starts to shrink. The measurable displaces the meaningful. What can be formalized begins to stand in for what is real. We start to talk as if the quantity of information were the essence of the thing, rather than one important aspect revealed under one powerful abstraction.

The uncertainty model, then, should be understood as a triumph of scope-limited precision. It tells us how to think about information as formal surprise. It does not tell us what information becomes when it is interpreted, remembered, believed, doubted, organized into knowledge, or woven into intelligent action. Those questions lie outside its frame.

But once information has been formalized this way, a second great step follows naturally. If information can be quantified, then it can also be engineered. It can be encoded, sent, protected against noise, and recovered. That is where the modern theory of transmission enters.

4. Information as Transmission and Encoding

Once information had been disciplined as a formal quantity, it became possible to ask a new kind of question: not simply how much information there is, but how it can be carried reliably from one point to another. This shift produced one of the defining achievements of the modern age. Information became a problem of engineering.

The elegance of the transmission model lies in its discipline. It asks how a source can send information across a channel to a destination despite noise, distortion, interference, and limitation. Once the question is posed this way, a remarkable set of ideas becomes possible: encoding, compression, redundancy, bandwidth, error correction, signal recovery. Information is no longer just an abstract quantity. It is something that can be moved, preserved, optimized, and reconstructed.

The practical consequences of this move are almost impossible to overstate. Telecommunications, digital computing, internet infrastructure, wireless systems, storage devices, streaming platforms, and countless other technologies depend on it. The modern world was built, in no small part, by learning how to make information survive the journey.

This success helps explain why the transport model became so culturally dominant. It solved urgent problems with astonishing power. A voice could travel across continents. A file could be compressed and restored. Noise could be managed. Signals could be encoded and decoded at scale. What had once seemed fragile could be made robust. It is only natural that a concept that reshaped engineering would also reshape common thought.

And yet the triumph of transmission invites a familiar mistake. Because communication theory solved the problem of reliable conveyance so effectively, it became easy to treat conveyance as the central fact about information itself. Information began to look like whatever can be sent, stored, and recovered. The channel became the conceptual stage on which information's whole drama seemed to unfold.

But reliable transmission is not the same as understanding.

A message may arrive perfectly and still fail completely as knowledge. A sentence can cross a channel without error and remain meaningless to the receiver. A false report can be encoded flawlessly. A digital file can be preserved bit for bit while its relevance vanishes. A nonsense string can be transmitted with impeccable precision. In every case, the channel model has succeeded on its own terms. Yet the broader human questions remain open.

This is not a criticism of the model within its proper domain. On the contrary, its greatness lies precisely in how much it accomplishes without asking what the message means. Communication theory solved the problem of reliability, not the problem of understanding. It did not claim to explain truth, knowledge, or cognition. Those omissions were methodological decisions, not intellectual failures.

The difficulty begins when the method becomes a worldview. The cultural prestige of transmission encourages the idea that information is fundamentally whatever can be encoded and moved. That intuition then radiates into other domains. We begin to imagine minds as channels, knowledge as storage, cognition as transfer, and intelligence as increasingly sophisticated signal processing. Each analogy contains some truth. None can bear the whole weight of the reality it is asked to explain.

A perfectly transmitted falsehood is still perfectly transmitted. That is a simple sentence, but it marks the boundary of the model with unusual clarity.



Channels can preserve form without guaranteeing truth. Codes can protect sequence without generating meaning. Recovery can succeed without comprehension. The transport model is a masterpiece of engineering. It is not yet a complete philosophy of information.

Its success, however, points toward something deeper: abstraction itself. The narrow theories won because they reduced complexity so effectively. They gained power by refusing to ask every question at once. That is the next thing we must understand.

5. The Power of Abstraction and Its Price

Good science often advances by not trying to explain everything at once. It gains force by selective attention, by idealization, by stripping away the clutter of lived reality until a tractable problem emerges. This is one of the deepest virtues of disciplined inquiry. Without abstraction, there is no precision. Without precision, there is little cumulative progress.

The narrow theories of information belong to this noble tradition. They became powerful because they left things out. Communication theory did not try to settle the meaning of a sentence, the truth of a claim, or the structure of understanding. It isolated the problem of formal information and reliable transmission. That act of narrowing gave it clarity, measure, and applicability. A blurred concept became operational. A field became engineerable.

This is why abstraction should not be treated as a vice. A map is powerful precisely because it leaves out most of the world. A railway timetable is useful because it does not try to capture every lived detail of a journey. An architectural plan can guide construction because it is not the building itself. Omission is not failure when it is purposeful. It is often the source of a model's strength.

But omission acquires a different status when its limits are forgotten.

A map becomes misleading when treated as the territory. A plan becomes absurd when mistaken for a lived house. A timetable becomes comical when used to explain the weather, the crowd, the fatigue of travel, and the meaning of arrival. In the same way, a scientific abstraction becomes philosophically distorting when its success in one domain encourages us to treat it as a complete account of reality.

This is what happened, at least in part, with information. The narrow theories succeeded so brilliantly in formal and engineering settings that their vocabulary began to migrate outward. Once information could be measured, encoded, compressed, and transmitted, the temptation grew to identify information as such with whatever fit those operations. Methodological reduction quietly hardened into metaphysical reduction.

That hardening is subtle. It often appears merely as habit. We start to speak as though information is fundamentally content in transit, as though knowledge is stored content, as though cognition is elaborate processing, as though understanding is the efficient handling of symbols. None of these claims is wholly absurd. Each rides on the prestige of genuine scientific success. But together they shrink the conceptual space too quickly.

The price of abstraction, then, is not error in the narrow sense. It is omission elevated into ontology. A model that intentionally leaves out meaning, truth, memory, or interpretation may still be exactly right for a certain purpose. Trouble begins only when later thinkers inherit the abstraction without remembering what was sacrificed to achieve it.

This is why the narrow theories should be admired and resituated at the same time. Their power came from focusing on what could be formalized. Their limitation arises when formalization is confused with total explanation. Science needs abstraction. Philosophy must remember its cost.

And that cost becomes visible as soon as we leave the controlled world of channels and enter the more unruly territories of knowledge, life, and mind. There, what was omitted returns as necessity.

6. What These Theories Leave Out

The narrow theories of information do not fail because they are wrong. They fail because they are silent about too much.

That silence was deliberate. It was not an oversight or a philosophical accident. It was the condition of their power. By setting aside meaning, truth, knowledge, interpretation, memory, and judgment, the classical theories made information tractable. They did not ask what a message means, whether it is true, whether it improves understanding, or whether it becomes part of durable knowledge. They asked questions that could be answered with rigor: how much uncertainty is reduced, how efficiently something can be encoded, how reliably it can travel through noise, how much distortion a channel can tolerate. These were brilliant questions. They were also bounded ones.

The first and most obvious omission is meaning. A message may be transmitted with perfect fidelity and yet mean nothing to its recipient. A sentence in an unknown language can arrive intact, letter for letter, while remaining inert. A random string of symbols may carry high formal information in one sense and no intelligible significance in another. The narrow theories do not explain this gap because they were not built to explain it. Their models succeed precisely by bracketing the question of meaning and focusing on formal properties that can be measured without semantic dispute.

The second omission is truth. A signal may be encoded flawlessly and delivered



without error, yet what it carries may be false. A rumor, a lie, and a fact can all move through the same channel with equal efficiency. From the standpoint of transmission, a falsehood and a truth may look identical. But from the standpoint of knowledge, the difference is enormous. A theory that can explain how content moves without explaining whether the content tracks reality is not yet a theory adequate for knowledge-bearing systems.

The third omission is understanding. A system may reduce uncertainty without becoming wiser. It may receive inputs, register differences, update probabilities, and still fail to grasp the larger significance of what has occurred. One can be informed in the narrow sense and still remain ignorant in the richer one. This is why reduced surprise is not the same as improved judgment. Uncertainty reduction tells us something about formal change in a system's state. It does not tell us whether the change amounts to insight.

A fourth omission is the distinction between information and knowledge. The narrow theories can tell us that a message was received, that a code was decoded, that a signal was reconstructed, or that uncertainty fell. But they do not by themselves explain how some informational episodes become stable, usable, revisable organization within a system. They do not explain why a memory can guide action, why a principle can endure, or why understanding can deepen. They illuminate transfer and formal variation, not the emergence of durable cognitive structure.

Then there is life. Living systems do more than send and receive. They regulate, preserve, adapt, repair, and remember. They do not simply move information across channels; they organize themselves through it. The narrow theories can illuminate certain formal aspects of communication within or about living systems, but they do not exhaust what information is doing in an organism. A cell, an immune response, a developmental process, or a memory-guided action cannot be adequately understood as mere channel traffic.

Finally, there is cognition and intelligence. Minds do not merely encode and decode. They interpret, revise, compare, infer, imagine, retain, forget, and act under conditions of uncertainty that are not just statistical but meaningful. A theory powerful enough for telecommunications may still be too thin for thought. The fact that a system can process signals, transmit symbols, or optimize throughput does not mean it possesses understanding. What is excluded from the narrow models by design returns immediately when the subject shifts from channels to minds.

This is why the narrow theories are both indispensable and insufficient. They are indispensable because they solved their own problems with extraordinary force. They are insufficient because the problems they left outside the frame do not disappear merely because they are hard. Meaning does not vanish because it resists measurement. Truth does not vanish because channels are neutral

about it. Knowledge does not vanish because uncertainty can be formalized. Interpretation does not vanish because coding schemes can be optimized.

A theory can be exact within its frame and still be silent where later inquiry most needs speech. That is the position of the narrow theories in this book. They are not errors to be discarded. They are disciplined achievements whose boundaries must be remembered.

7. Why This Matters for the Rest of the Book

The point of this chapter is not merely historical. It is foundational. If the concept of information remains confined within the narrow models that made it formally powerful, then every later question in this book will be posed too shallowly from the start.

Take knowledge. If information is treated mainly as uncertainty reduction or successful transmission, then knowledge begins to look like a special case of storage or delivery. But knowledge is not just content that arrived. It is organized, retained, usable, revisable. It participates in judgment and action. A framework designed for channels does not yet explain how information becomes something stable enough to guide a life or a mind.

Take meaning. A message can arrive intact and still fail as significance. Meaning requires interpretation, relation, and context in ways that transmission theory does not attempt to model. If we forget that limitation, we begin to confuse communication success with semantic understanding.

Take living systems. Organisms do more than encode and send. They regulate, adapt, remember, preserve continuity, and organize themselves in relation to their environments. To describe all of this in the language of channel transfer alone is to miss the richer forms of informational organization at work.

Take cognition. Minds do not merely pass signals along. They compare, revise, infer, imagine, retain, and sometimes understand. A theory adequate for communication may still be inadequate for thought. What works brilliantly for channels may fail for minds.

This is why the rest of the book begins where the narrow theories stop speaking. Their precision was necessary. Their silence is equally important to notice. The later chapters will ask how information becomes meaningful, how it differs from knowledge, how it relates to structure and observer, and how it participates in cognition and intelligence. None of those questions can be answered well if the channel model remains the unexamined horizon.



The task ahead, then, is not rejection but enlargement. We need a theory broad enough to preserve the achievements of formal rigor without allowing those achievements to become a prison. The concept of information must remain precise enough to be useful and rich enough to travel across the domains where it truly matters.

That is why the next chapter turns from respectful critique to constructive ambition.

8. Conclusion

The narrow theories of information triumphed for good reason. They solved real problems with extraordinary elegance. By treating information as uncertainty reduction, by making transmission analyzable, by turning encoding and noise into formal objects of study, they helped create much of the modern technical world. Their success was earned.

But success is not completeness.

The very abstractions that gave these theories their power also set their boundaries. They bracketed meaning, truth, knowledge, memory, and interpretation not because these things are unreal, but because they complicated the problem beyond what the theory was designed to solve. That methodological narrowing became philosophically misleading only when its limits were forgotten.

This chapter has therefore tried to do something modest but essential. It has not discarded the narrow theories. It has restored their scale. They remain indispensable where formal communication and transmission are concerned. But they cannot, by themselves, answer the larger questions toward which this book is moving.

We do not outgrow precision by abandoning it. We outgrow it by placing it within a larger understanding. A broader theory of information must preserve the achievements of rigor without inheriting the blindness of omission. It must explain why data, signals, messages, uncertainty, and transmission all matter, while also making room for meaning, truth, knowledge, life, cognition, and intelligence.

That constructive enlargement begins with the next question, one the narrow theories could not answer by design:

What would a genuinely general theory of information have to include?

Toward a General Theory of Information

What the narrow theories could not provide was not rigor, but breadth. They gave us astonishing precision wherever information could be formalized as uncertainty, transmission, encoding, and recovery. Yet the very discipline that made them so fruitful also ensured that they would stop short of the larger questions now pressing upon us. If information is not exhausted by data, signals, messages, channels, and codes, then what kind of concept would be broad enough to include all of these without collapsing into vagueness? What sort of theory could preserve the gains of formal clarity while also making room for meaning, knowledge, life, cognition, and intelligence? At that point, criticism is no longer enough. The argument must become constructive.

That constructive turn begins in the next chapter. There we move from the power and limits of narrow theories to the ambition of a general one. The question will no longer be only what classical models explain, but what a fuller account of information must include if it is to serve as a genuine foundation. A general theory of information must be able to travel across domains without losing precision, to speak of structure without dissolving into metaphor, and to explain why information can appear in communication, biology, memory, and thought without being reducible to any one of them. Chapter Three takes up that challenge. It is where the conceptual horizon of this book begins to widen.

