Chapter Three: *The Logic of Discovery*
The Logics of Causality and Material Analogy

From Observation to Understanding

Before we begin our actual analysis of the Logic of Discovery, we must introduce and explain several issues that are basic to the Logics of the Material World. This is due, in large part, to the fact that when we investigate the material side of our experience we must employ terms and concepts whose signification includes *reference* to material objects, in addition to *meanings* in terms of Ideas. Material Loigcs are concerned with not only determining how the Material World "hangs together", as it were, but also (and fundamentally) with *understanding and using* what is called *Natural Language* to make our material determinations. This is not the case, as we shall see, with the Logic of Corroboration; for there we simply stipulate the significance of the symbols in terms entirely of very limited *meaning*, while foregoing all *reference* to the Material World whatsoever. In effect, this makes the Deductive Logic of Corroboration a much simpler affair than the hypothetical Material Logics of Abduction, Adduction, and Induction. Accordingly, we shall begin here with a discussion of several aspect of Natural Language, including the nature of philosophical Understanding, the functions and uses of Language, definition, and the general structure of hypothetical arguments. We begin with nature of Explanation and scientific Understanding.

In Aristotle's text on the *principle* Ideas of Philosophy,[1] the Peripatetic philosopher begins by insisting that all humans, because of our "nature", "desire to know. An indication of this is the delight we take in our senses; for even apart from their usefulness they are loved for themselves; and above all others the sense of sight." Although we can make much of this remark (and certainly, much has been made of it over the millennia), all that we need to take from it now is the implication that Perception—to which capacity Aristotle's phrase "the sense of sight" refers—is a type of knowledge. However, as we learned in Chapter One, there's knowledge and there's knowledge.[2] And so, to fall back, once again, upon Bertrand Russell's epistemological distinction, we will say that Perception produces an instance of what he called "knowledge of".[3] In our *perception* of

Reality, we have a type of *knowledge* in which we are aware *of* objects that are co-present with us—we know, at the very least, that *they are there*. This "knowledge of" objects is the product of a type of Perception that we shall call *incipient*.

Incipient Perception—which allows us only the knowledge that *something is*—is what new-borns and infants (and the "inexperienced", in general) experience: they *know of* objects, they perceive things, but without *knowing what to expect of* them.[4] And although there is a certain usefulness to this type of knowledge—it allows us to *know of* specific objects as "surrounding" us—this is not yet the "usefulness" to which Aristotle refers. For this, we need a type of Perception that allows us *not merely* to know that we are in the midst of surrounding objects, but also to *make our way* about, and *have our way* with, these objects. This is the true *utility* of Perception, for the Reality that our perceptual experience makes present for us is something that is often threatening and, as a matter of course, entails objects and events that require our intervention. For this, it is helpful to know more than just that objects are present; for we need to *know* what to expect *of* these objects, both when we perceive them and when we handle them. Accordingly, we have an evolutionary advantage when the objects and events we perceive are *familiar* to us. If Perception were merely of the incipient type, lacking the ability to *recognize* what we have seen *previously*, each individual perceptual experience would seem like an isolated and original experience; and each object we encounter would be something unfamiliar. As a result, we would not know what to expect of the objects we encounter, and thus our capacity to act and react would be limited.

Fortunately, Perception is an *adaptive* capacity, which means that it develops over time in order to increase its functional utility.[5] In particular, as we persist in our involvement with objects, we *learn* to scrutinize and take note of the objects. In so doing, we say that we *observe* what we perceive; and by *observation*—by noting what is *meaningful* about the objects—we develop expectations about possible future encounters. More importantly, however (and perhaps, most importantly), we *record* our perceptual experience—our observations—in Long-Term Memory (without which there could be no *learning*); and this allows Perception to mature, as it were, accumulating more observational information. Original, *incipient* Perception is more or less "un-informed" Perception, in the sense that we are "seeing an object *without knowing* what to expect *of* it". But with the natural maturation that comes of learning (which involves Memory) through repeated observation of and informed interaction with the objects, perception comes to entail a "knowledge of" objects that includes these learned expectations. At this point, we say that our Perception is *intuitive*; it is Perception always "informed" by its own history, so to speak. *Intuitive* Perception is what the "experienced" experience: they are familiar with the objects they *observe*, and this familiarity of what we observe—the result of perceptual *intuition*—is an integral part of basic Experience.

Observation and Experience thus go hand-in-hand; in effect, our basic Experience rests on the accumulated *knowledge of* objects through repeated or sustained *observation* *of* those Objects. This too is a type of "knowledge of"; and it can be very useful, as Aristotle has suggested. But even this is not the full utility of Perception, for neither Observation nor Experience (of the type just described) is "knowledge about" objects. That, by definition, is knowledge by "description", for which language is a requirement. Clearly, language is not necessary for Perception, even *Intuitive* Perception; experience accumulates even in the absence of language, as the Great Apes evince. But there is no description without language; and when language *is* present, it allows for this new type of Knowledge: "knowledge about". This type of Knowledge—embodied in linguistic expressions that describe the objects we encounter—is then added to our "basic experience"; and this in turn allows for the continuing development of knowledge about objects by description. The linguistic expressions serve to clarify our ideas about how things work, by expressing—that is, making explicit—our tacit and thus implicit expectations involved in our *knowledge of* objects by acquaintance. These linguistic expressions thus tend to make our implicit knowledge of objects more *clear*, as it were, and from one of the Latin words for 'clear'—in particular, the word 'planus'—we call these clarifications Explanations.

Explanation—in the sense of "knowledge about"—is a requirement for scientific Understanding; and since language is essential for both explanation and understanding, it would be helpful to know when language became a part of Experience. Unfortunately, in our current state of knowledge we are not able to determine the precise date in our history at which language first emerged; it may be as much as 1.8 million years ago.[6] However, our concern is not whether the earliest types of humans had language, but rather with the nature of the language of our immediate evolutionary ancestors. By the time of modern humans—*Homo Sapiens Sapiens*, who emerged some two-hundred thousand years ago—and in particular by about thirty-thousand years ago, language had matured to a point at which it was capable of what we call modern *syntax* or sentence-structure. This allows for the expression of fairly complex "knowledge about" objects, and it is very likely that around this time humans began weaving what we now call Mythology: intricate narratives that express human concerns. These ancient stories—such as the Creation Myths of the earliest Eurasians, or the Emergence Myths of Native America—served as our earliest explanations of how the world, and the objects it contains, came to be.

This is truly the beginning of our *understanding* the world; the sad truth, however, is that most (if not *all*) of these stories are false—often blatantly so. These ancient myths tell of monsters and gods, and many other sorts of objects that, as far as we know, simply do not exist. As the History of Ideas teaches us, mythical narrative emerged when Humans did not understand any of the intimate details about the objects they encountered, other than themselves. As a result, our earliest narratives are cast in terms of human properties and activities, in what we call the Personification of the objects in the world. Even the world itself could not escape this maneuver, for the word 'world' literally means "Old Man"―and it is a remnant from the times when more or less everything was personified. As the myth goes, this Old Man can be seen watching over his world: the rising Sun on one horizon and the setting full Moon on the other are his two eyes, with the Moon being the Evil Eye.

Of course, the most ancient of myths from around the world are recognized today for what they are: the projection of human imagination upon what we now know as the merely physical world. As such, their immediate survival value had nothing to do with the scientific understanding of reality. Rather, these myths served to placate the anxieties of intelligent ancient humans who were yet largely ignorant about much of that with which they had to deal; and it is for reasons such as this that these myths have survived for some thirty-thousand years. Ultimately, however, these stories are false, and there are no good reasons for accepting their pronouncements with respect to the physical world. In other words, the Sun is not a god, it is just a big ball of fire in the sky. The only "justification", if we can call it that, for these age-old stories is that the satisfy certain *emotional* needs, and thus the type of belief involved here is what we shall call Pure Belief. As we saw in Chapter One, an Idea is a Logical Form expressed by human utterance, typically a declarative sentence. A Pure Belief, then, is an Idea that someone "holds on to" simply for the emotional charge. Our belief that there is a god―the Old Man―in the sky watching over us is just such a belief: it helps satisfy our need for security, but other than that there are no good reasons for accepting this belief. Admittedly, the wind could be the breath of the Old Man, and the Milky Way could be his backbone, as the details of the myth insist. But these natural events/objects could also be something else. The Greeks, for instance, believed that the Milky Way was literally just that―a path of milk spewed from the mouth of the infant Herakles while he was suckling at the breast of his mother, Hera. Clearly, we humans were clutching at straws.

The point here is that the type of belief that is involved in our earliest "explanations" of the world, produced in order to help us understand our situation, were not realistic explanations at all. Rather, they were expressions of our emotional concerns. As a result, although they allowed us to better understand ourselves, these beliefs did not actually allow us to better understand the world in which we live. For this, we require different forms of Belief: forms that involve realistic ideas educed from an intimate observational knowledge of the actual physical world; and, ultimately, forms of belief that―following the suggestions of Francis Bacon―allow for the *induction* of general Axioms that can themselves be used to *deduce* predictions that can be checked by further experimentation. Only these mature forms of Belief, forms that have been developed only in the last four hundred years, allow observation and experience to develop into scientific explanations and philosophical understanding. Accordingly, we introduce the notion of the three *Stages of Belief*.

The Three Stages of Belief:

The notion of the "stages" of Belief entails the relation between a Belief and the type of "grounding", either emotional or rational, provided for the Belief. For example, the first of the Three Stages of Belief is just the Pure Belief mentioned above, for which we have only emotional grounds. In contrast, the second stage, called Sound Belief, requires a type of grounding that involves facts and ideas that are *Logically*—and in this case, *materially*—related to the Belief. And finally, the third and last stage, called Justified Belief, provides a purely *formal, deductive* Logic as its ground. In effect, these three stages of belief represent both the overall development of the human intellect throughout our evolutionary history, as well as the personal intellectual development of each individual human, from birth to rational maturity (given the appropriate education, of course). For the sake of clarification, these three Stages of Belief are summarized as follows:

1) *Pure Belief*: The Emotional Conviction that an Idea is Worthy of Assent

The *Emotional Approach* to Knowledge
Determined by Emotional Charge—the Feeling-Tone of the Belief

2) *Sound Belief*: Pure Belief plus Facts and Ideas related to the Belief

The *Material Approach* to Knowledge
Determined by Causality, Material Analogy, and Semantic Analysis

3) *Justified Belief*: Sound Belief plus Deductive Methods and Models

The *Formal Approach* to Knowledge
Determined by Formal Analogy, used to corroborate the Material Approach

As we see in the summary, Pure Belief takes what we call the Emotional Approach to Knowledge, which is to say that what passes for knowledge at this stage are beliefs, pure and simple, beliefs whose only ground for assent is an emotional charge. An example of a Pure Belief is the belief that somewhere "above and beyond" the Universe there is a God who created the world and who continues to watch over it. This belief may or may not be true; but in either case there simply are no material or formal grounds that may be used to support or justify the belief. Admittedly, the world often looks as though it were created, in which case we might assume that God, the Creator, created it; but the appearance of creation could be explained in other ways, such as evolution or even mere serendipity. Ultimately, then, our only "justification" (which, in this case, is a mere “rationalization”) for assenting to this belief is that it satisfies our emotional need to feel safe in the world (or some such emotional need). And in general, this is the case with pure beliefs: they have only an emotional *charge* as their ground.

In contrast, the next stage of belief, Sound Belief, connects our pure beliefs to facts perceived and ideas derived from other instances of observation of and experience with the world. At this second stage of belief, other objects and facts that are causally or analogically—which, again, is to say *materially*—related to the Pure Belief are brought in as additional support for the belief. The most advanced form of Sound Belief comes only after the realization that Causality and Analogy, rather than (the magical notions of) Contagion and Resemblance, are the true intellectual tools of knowledge. Sound Belief uses the Material Approach to Knowledge, an example of which is the belief (although an admittedly false belief) that the four so-called Sacred Colors of Mythology—the colors Black, White, Red, and Yellow, that early Greek medical doctors found in the eyes of their patients—are representative of the four bodily liquids known as humours—that is, Black Bile, Phlegm, Blood, and Urine, respectively. According to Greek medical science, these “humours” exist in the human body and purportedly determine our health. And considering the fact (which actually is true) that the presence of yellow color in the eyes often is symptomatic of liver disease, or that bloodshot eyes are often indicative of general malaise (if not in fact a hangover), the Greek physicians clearly did not accept this belief merely upon emotion grounds—additional facts and ideas, cognitive grounds, were also involved. Thus, although the belief turned out to be false, its relation to other ideas and facts about the material world *accepted at the time* gave this belief at least a modicum of rationality, and the belief thus may be said to have been, at the time, a Sound Belief. Our knowledge of the material world, however, is constantly changing; and since Sound Belief takes the Material Approach to Knowledge, it is highly possible that the discovery of some new fact or idea about the Material World will undermine the supposed soundness of a currently accepted belief, even to the point of contradicting the truth of the belief (as was, of course, the actual historical situation with respect to the belief in the four bodily Humours). Apparently, even though Sound Belief is more reliable (realistically) than Pure Belief, it none the less capable only of contingent knowledge: knowledge that can only be described as “probably” correct.

Last but not least, Justified Belief, the third stage of belief, takes what is called the Formal Approach to Knowledge. In this approach, which produces actual *scientific Understanding*, a few basic assumptions about the world—beliefs that we call *Axioms*—are used to create what is known as a formal, deductive theory about our accepted Sound Beliefs, thereby providing *formally*-Logical corroboration for these originally *material*-hypothetical beliefs. To illustrate this process of developing scientific understanding, we note that, using the material approach to knowledge, scientists have discovered that all protons *that have been measured* have exactly the same mass; that is, all *measured* protons are known to be *analogous* with respect to their mass. Then, by extending this analogy to include the many protons that have *not* been measured, we produce the *inferred* belief—in this case, an Inductive generalization—that "*All* protons have the same mass." Now, this belief may in fact be false, since so many un-measured protons, perhaps billions, are involved (again, Sound Belief is contingent). But the belief is never the less said to be a *Sound scientific Belief*, because it has *material* (rather than merely *emotional*) grounding: there are numerous *other* material objects—such as electrons—and events—such as the discovery and measurement of electrons—that tend to support our belief about the newly discovered protons. Never the less, this sound type of belief often leaves us wanting a more reliable form of belief—one whose reliability is great enough to say that our belief is actually *knowledge*.

As a final step, then, we turn to the Formal Approach to Knowledge, in which we create a *logical theory* about the world based upon as few assumptions (called axioms) as we can manage, none of which assumptions say anything about (for example) the mass of protons. If, however, at some point in its development, the logical theory that we deduce from the axioms *requires* that all protons have the same mass, then we say that the theory has *demonstrated* that our Sound Belief about protons *must* be true, and this is what we call a Justified Belief. That is, according to this theory all protons *must* have the same mass, for, *if* our basic assumptions (the Axioms) are true, then whatever is deduced from them in the theory *must be true* as well (since this is the way Deductive Logic works). Accordingly, we say that we have produced *logical justification*—corroborating evidence—for the *sound* inductive generalization that all protons have the same mass. In effect, we have transformed the merely contingent Sound Belief that *all protons should display the same mass when measured* into the more reliable and necessary Justified Belief that *all electrons must have the same mass* if our basic assumptions about the physical world are correct. Consequently there is no need to continue measuring protons: our deductive theory has demonstrated that, by Logical *necessity*, all protons must have the same mass.

As defined, these three Stages of Belief are differentiated according to their method of *grounding* the involved beliefs, of tying these beliefs to the world itself. Pure Belief provides only *emotional* conviction as a type of grounding for our beliefs, and since this type of belief does not involve other aspects of the physical world, it is the least reliable form of "grounding". To insure the reliability of Belief, then, we create Sound Belief, which provides some form of *materially contingent* grounding to our emotional convictions (such as that found in causal and analogic relations among objects). Sound Belief thus offers the first form of *corroborating* evidence to validate our beliefs, and as such it produces a somewhat more reliable type of belief than Pure Belief. And finally, Justified Belief provides a *formally necessary* grounding, the second type of corroborating evidence, to our Sound Beliefs. In combination, these two forms of logical justification produce what is certainly the most reliable form of belief—the hypotheticodeductive form―exemplified, for instance, in the unparalleled accuracy of Einstein's Relativity Theory and the theories of Quantum Mechanics developed by Bohr and others.

Traditionally, all three stages of belief have been held to be instances of knowledge, and for general purposes of communication this way of speaking is serviceable enough. Philosophers, however, have preferred to reserve the term 'knowledge' for the last two forms of belief only, if not solely for the last form―Justified Belief. Accordingly, in our investigation we shall reserve the phrase "scientific knowledge" for the type of reliable belief produced by the Formal Approach to Knowledge: Justified Belief. In terms of the two Applications of Logic explained in Chapter One, Sound Belief is the product of the Logics of Discovery, while Justified Belief―true scientific knowledge―comes for the corroboration of Sound Belief by means of Deductive Logic.

Speech Functions and the Uses of Language

Obviously, the Logical forms of thinking that we have been discussing do not cover all of the various uses to which we can put natural language. Rather, they constitute a portion, as it were, of the full range of linguistic utility, which includes poetic, emotional, and sometimes even what is called phatic communication. This last form of linguistic utility is oral communication whose only function is to open, maintain, or close the channel of communication. To fully appreciate the Logical utility of language, it is helpful to understand all of the various possible forms of communication; and for this, we will fall back upon the basic structure of communication in general. Consider, then, Figure 3-1, in which we see the basic Structure of Communication (in the box at the bottom of the figure), as analyzed by Claude Shannon and Warren Weaver when they developed their mathematical theory of communication and information. As the illustration shows (on the lower of the two levels of the bottom diagram, labeled the *Energy Level*), communication begins with a Transmitter that originates and transfers a Signal (not shown) across a Channel to a Receiver.[7] The Transmitter, which sends its communications across the Channel, can be either a living organism or a mechanical device, such as a radio transmitter, a computer-network communication card, a human mouth, etc. The Channel can be air waves or radio waves, or a computer network cable, and so on; and the Receiver, which takes the Signal from the Channel, may or may not be the same kind of thing as the Transmitter. The significance here, for our purposes, is that communication is a one-way process that uses some kind of energy to transfer some kind of information *from* a source *to* a destination.[8] Further, as we see in Figure 3-1, the Structure of Communication is analyzed on two levels, the second of which in the diagram is called the *Information Level*. Here we find the three components that parallel the three components of the lower, *Energy* level. First, the Encoder, parallel to the Transmitter below, prepares the Signal for transmission along the Channel by *coding* the Information in the appropriate form, according to the rules of the Code, thus transforming the Signal into a Message. This Signal-Message is then given to the Transmitter, which uses its Energy to send the Signal across the Channel, where it is taken up by the Receiver and then given over to the Decoder. The Decoder then reverses the process carried out by the Encoder, deciphering the Message and interpreting its significance according to the same coding rules used by the Encoder.

Combining the two levels of communication, we note that, under this analysis, the structure of communication is comprised of six components, and to each these semiotician Roman Jakobson has assigned a specific speech function, as shown in the upper diagram of Figure 3-1. As we see, Jakobson actually renamed most of the Shannon and Weaver components, leaving only the Message with its original name. Nevertheless, the names given in the figure (such as Code for Encoder and Contact for Channel) are straightforward enough modifications of the original names. Associated with each of the six components is one of Jakobson's six *Functions of Speech*, which he derives directly from the elements of a speech event. In our analysis we will consider each function in turn (though only briefly enough to get a handle on what Jakobson is trying to say).

First, then, we have the Phatic Function, which is perhaps the most basic function of communication. The label *Phatic* (from the Greek 'phasi' = 'to speak', which is also related to the Latin 'fess', as in 'professor' = 'one who speaks forth') refers to the actual speech act itself, and in Jakobson's theory it focuses on the Contact component of communication—the *channel*, itself. Phatic *communication*, then, is communication that lacks meaningful content, at least in terms of what we typically mean by the word 'meaningful'; its "referent", so to speak, is the actual *contact* between two communicators. The type of figurative language known as Persiflage, for instance, a form of "idle chatter", is in a very real sense purely phatic discourse, because *as persiflage*—that is, as discourse that is really no more meaningful than whistling (which, in Latin, is 'persiflare')—it serves merely to allow the "speaker" to make audial *contact* with the hearer. In effect it is communication by means of mere *Signal*, without any real concern for a *Message*. The focus of Phatic communication is on such things as familial and social bonds (as potential channels of communication) rather than on communication itself. These bonds are often established and strengthened by phatic acts, such as when a mother strengthens the bonds between her and her infant child by echoing the infant's googooing noises. Phatic communication was very likely the earliest form of communication developed by primates, who could use it to locate each other in the thick canopy of a forest, as well as to cement the social bonds established, for instance, by grooming.

The second speech function, the Expressive function, involves what Jakobson called the Sender, from whom the Expressive Function of language issues. The focus of this function is upon the *emotions* of the Sender, for this function allows the Sender to express his or her personal, inner feelings, as well as other inner states, the status of which the Sender wishes to convey to others. Very likely, the Phatic communication that is rampant at a very early age (if not from the outset) among some primate groups was also involved in such Expressive communication. Particularly in the act of grooming, social bonds are strengthened in large part by the act of grooming itself, which requires physical contact between communicating primates. In this case, the burden of establishing contact by means of Phatic utterances is less pressing, in which case the Phatic utterance is free to serve other purposes—such as the expression by the Sender of his or her inner states. This is what we call the Expressive function of language, and its typical focus is upon communicating the *emotions* of the Sender to the Receiver.

As for the third function, we find associated with the Receiver what is called the Conative Function, where the word 'conative' refers to the *will* of the Receiver as well as to our attempts—through imperatives and directives, for instance—to drive and perhaps direct this will. The Conative function allows our language to generate or effect the actions of other people, such as when we yell "Look out" at someone, in order to make them jump out of the way. Primates utilize this function when, for instance, they issue signal-calls that indicate the presence of a predator; their intention is clearly to get their fellow primates to scurry to safety. And of course, when politicians call for their constituents to get out and vote, or advertisers encourage consumers to go out and buy their products, they are utilizing the Conative function of language. The three functions associated with the *Energy Level*, then, are the Phatic, the Expressive, and the Conative.

Jakobson's four Speech Function, the Poetic Function, is found on the *Information Level*, and it derives from a focus upon the Message's vocal, rhythmical, and other poetic characteristics. In this function Jakobson includes such poetic aspects of language as meter (which we find in prose as well as in poetry), sound-repetition (such as alliteration), and diction. The focus here seems to be upon "dressing up" our discourse with such embellishments as are found among those figures of speech that Aristotle calls Schemes (as opposed to the Tropes), which alter the morphology as well as the syntax of a sentence (with rhyme being a prime, familiar example). Next, as the fifth function, Jakobson derives what he calls the Metalingual Function from his Code element, which is his term for Shannon-and-Weaver's Encoder component. As it turns out, however, "coding" is just an alternative phrase for the paradigmatic or semantic aspects of language, which allow us to flesh out our sentences with full-bodied meaning. Typically, the Metalingual Function involves such matters as "questions about the meaning of words and so on",[9] as Jakobson puts it. And as we shall see soon enough, "questions about . . . meaning" will be critical in our studies of both Formal and Material Logic. Finally, Jakobson's sixth function, the Referential Function of language, derives from what Jakobson calls the Context of the Message (his version of the Decoder), and refers to the fact that most human discourse, as we have noted above, is intended to convey Information that makes *reference to objects* or realms of the so-called external world. By focusing our discourse upon our culture, for instance, as well as upon the society of humans in which we find ourselves immersed, we put our language to the task of constructing and explaining the very “world’ in which we “live and move and have our being”.

This completes our survey of Jakobson’s six Speech Functions, of each of which, for the sake of brevity, a summary is given below:

The Phatic Function:

Language whose focus is on the Channel. “A message primarily serving to establish, to prolong, or to discontinue communication.”; to check or open the Channel; or ping the Addressee (Jakobson). The paramount intent is *Channel maintenance*.

The Expressive Function:

Focus on the Addresser’s own attitude toward the content of the Message (Nöth). Often involves Interjectives or Exclamations. The paramount intent is *Expression* or *Affection*.

The Conative Function:

Focus on having the Addressee generate some action (Bühler’s Function of Appeal). It’s purest form is in the Vocative and the Imperative. The paramount intent is *Motivation*.

The Metalingual Function:

Language whose focus is Language itself, and Communication; often involving questions about the Meaning and Logic of what is being said. The paramount focus is *Encoding*.

The Poetic Function:

Language in which the focus is autotelic; that is, having no other function besides itself (Jakobson). Manifests itself in Poetry by a projection of the Paradigmatic Dimension of Language onto the Syntagmatic (Scholes). The paramount focus is *Prosody*.

The Referential Function:

Language whose focus is on the Cognitive aspect of Language (similar to Bühler’s Function of Representation); i.e., toward the Referent or the Context. The paramount focus is *Decoding*.

As we continue our investigations, our focus, naturally enough, will be upon the two functions that bear upon our subject, Logic; and these two functions are 1) the Metalingual Function (regarding, for the most part, Deductive Logic), whose focus is upon the Logic and meaning of the Message; and 2) the Referential Function (regarding, for the most part, the Material Logics), whose focus is upon how the meanings of the messages we communicate allow us to talk, and learn, about the real world.

The Forms and Uses of Definition

One important aspect of both the Metalingual and the Referential Functions of any natural language is that of *Definition*, the assignment of a specific *signification* to a specific *symbol*, by means of which the symbol can denote a specific *referent* or object, or connote a specific *meaning* or idea. Fortunately, our long-standing scientific tradition (and our even longer-standing narrative tradition) provides us with numerous and extensive instances of real-world definitions, and these may be used in our day to day lives and our sciences. At the same time, new words appear often enough, and this alone demands that from time to time we assign new meanings, that we often construct new definitions. Accordingly, a thorough understanding of the nature and process of definition would be helpful not only to produce these *new* definitions, but to understand the nature of extant traditional definitions as well. We shall consider then, albeit briefly, this essential semanticity of our *material* Logics.

The first thing we must note is that definitions assign *significance*—reference and meaning—to individual symbols; the symbol defined is called the *Definiendum*, while the definition itself is called the *Definiens*. For *material* logics, Definition is altogether indispensable, for in the Logics of Discovery our specific objective is to increase our store of knowledge about the real world (this being what makes our material knowledge ampliative). But this is patently impossible without the capacity for real-world references, without the capacity to talk about things. Accordingly, the process of scientific *discovery* puts a premium upon referential definitions, a tactic that the Logic of Corroboration can dispense with. There, in Deduction, we forego any reference to real-world Objects and focus solely upon the meaning (in a very limited sense) of the symbols. As a result, the theory of definition in the Logics of Discovery is somewhat more complicated than its corroborative counterpart, the Logical Matrices of Deductive Logic.

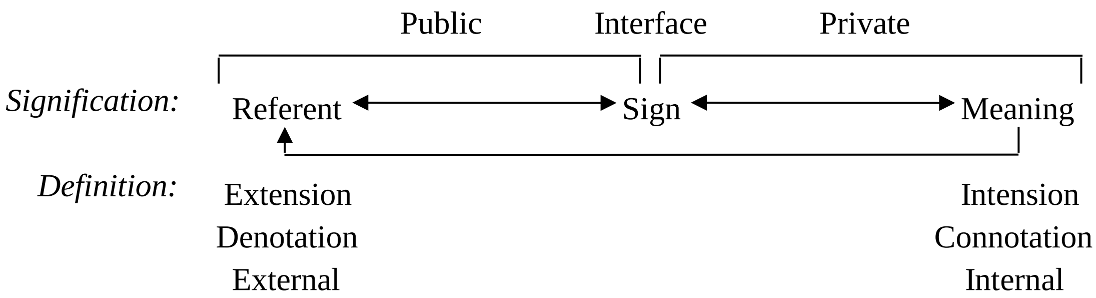
A second complication in the Logics of Discovery derives from the fact that, as we saw earlier, our *perceptual* experience of the real world finds its origin and basis in the process of *Sensation*, which delivers to our brains the raw *material* of our experience. But as we learned above, Sensation and Perception are not the same thing, and by the time any sensory material enters into our conscious understanding it is in the form of the Perception of whole Objects. These perceptual wholes, then—these *Objects*, rather than their distinct sensory components— are the basic items of our experience. And in order to distinguish between a perceptual Object and its sensory properties or features, we assume that the Objects are comprised of just these various sensory components, to which we must intentionally turn our attention. The sensory components, then—which we may call the Features of Objects—are viewed as being the elemental parts of the perceptual wholes; and in our attempt to understand Objects we can familiarize ourselves with what we now view as the details of the Object—its Features. When we do this, we say that we have come to know the *object* (the Whole) and its *properties* (the Features).

Of course, if this were the whole story of human consciousness, humans would possess nothing but the immediate knowledge of specific individual Objects and their sensory Features (as is the case with most other animals), and there would be nothing further to discuss. As it stands, however, humans do possess other, more advanced intellectual faculties than the mere consciousness or *knowledge* of Objects and Features. Among these are included 1) the capacity for Memory, which involves the ability to *recognize*—that is, "re-know" or "know again"—*this* Object as the *same* Object as the one that we knew in a previous experience, or to recognize *this* Features as the *same* Feature we knew from *different* experiences of the *same* Object; as well as 2) Observation, which involves (among other things) the ability to recognize and *identify* a specific, experienced Feature—one that we are perceiving *right now*, possessed by an Object given in perception *right now*—as being *similar to* a Feature of a *different* Object, one experienced at an earlier time. And this latter capacity—the ability to identify the *same* Feature in *different* Objects as being *common* to both—is extremely important, for it provides us with a means of organizing our knowledge of Objects and introducing a new level of Understanding. We can, that is, mentally "collect" our memories of all of the Objects that possess a common Feature, and from these "construct" a new "object" (and in fact a new *type* of Object), which we call a *kind*—thereby economizing our mental inventory. In this way, a Kind can be viewed as a unified collection of distinct Objects, much as an Object itself is viewed as a unified bundle of distinct Sensations. And these new mental or (as we say) *conceptual* "objects"—these newly formed *conceptual* Kinds—can then play a role in our understanding that is similar but at the same time supplemental to the role of *perceptual* Objects. Accordingly, Kinds take their place among the various "objects" that we say we know; and just as a perceptual object's *Features* allow us a more intimate *knowledge of* the Object, a Kind's *Member-Objects*—the individual perceptual objects that comprise the Kind—allows us to become familiar with what now serve as the details of the Kind. Subsequently, we view these two new, *logical* notions—Kinds and their Members—as having a structure somewhat analogous to the two fundamental, *perceptual* notions—Objects and their Features—and we now have in our understanding (at this point, at any rate) two types of items and their components: 1) the perceptual items or *Objects*, with their component *Features*; and 2) the conceptual items or *Kinds*, with their own brand of components, the *Members* of the Kind. Schematically, this may be represented as follows:

1) At the Level of *Perception* we find: Objects comprised of Features
2) At the Level of *Conception* we find: Kinds comprised of Objects

Although the full relationship between Objects and their Features, or between Kinds and their Object members, is rich and thus complex, the details of this relationship need not concern us here. For us it will suffice to note that if an Object is comprised of its Features, then, clearly, when we modify a specific Feature of an Object—either by replacing the instance of a Feature with another instance of the same Feature, as when we change a red apple's color to green; or by replacing the Feature itself for a different Feature, as when we change a red circle into a red square—we necessarily transform the Object itself, perhaps even changing it into a different Object. And the same is true of Kinds as well; if a Kind is comprised of its Member-Objects, then, when we modify the Members of a Kind—either by simply changing them, or by altogether *eliminating* a Member-Object—we necessarily modify the Kind. Features and Members, thus, in a very real sense, set the boundaries of—that is, they *delimit* or *define* (from the Latin 'fin' = 'bound')—Objects and Kinds, respectively; and, conversely, we may view an Object's Features as actually determining, and thus "defining", the Object, or a Kind's Members as defining the Kind.

Recalling the meaning of the word 'definition' given in above, it is clear that when we speak of a group of Features as "defining" an Object (or of a group of Members "defining" a Kind), as we have just done, we are not using the word 'define' in quite the same way both times (and hence the quote-marks used here). Above, it was stated that 'to define' means 'to assign a meaning to a *symbol* so that the symbol can refer to its Object'; here, in contrast, we are not defining symbols, but rather only determining Object and Kinds. Nevertheless, one of the two major forms of traditional definition is not unlike the *determining* of a Kind by its Members, and as it turns out, this type of definition is intimately related to the mathematical notion of *membership* in a Class. This form of definition is known as an *Extensional definition*, in contrast to *Intentional definitions*, the second major form of definition. In Intentional definitions (which we shall consider directly), a symbol *is* defined in terms of *meaning*. In contrast, for Extensional definitions the entities used to define the symbol are, as we have said, not the *meanings* that we assign to our symbols but rather the *referents*—the Objects to which symbols are said to refer in the second form of definition. The relationship of both of these forms of definition—Extensional and Intentional—to the structure of the Signification, which relates a Sign to both its Meaning and its Referent, is as follows:



Taking the Extensional definitions first, we note that the term ‘extensional’ derives from an essential Feature of many Referents, for Referents are often physical entities or *things* in the real world. Now, the primary Feature of a *thing* (in fact, the very Feature to which the word ‘thing’ itself *points* or refers) is its “*extension* in space”; the root of the word ‘extension’—the Latin root ‘-*ten*-’—being actually related to the English word ‘thing’ (which originally referred to anything *extended* or “stretched out” in space). An Extensional definition, thus, is one in which the signification assigned to the *symbol* consists of actual physical *things*, and one way to use this type of definition is to actually *point to* the things to which we want the *symbol* to *refer*. Accordingly, to give the Extensional definition of a word that is being used to denote a single physical Object—for instance, to thus define the word ‘ball’—I merely point to an actual ball and say “When I say the word ‘ball’ I mean *this physical object*.” This particular form of Extensional definition is called an Ostensive definition (‘ostensive’ means ‘shown or displayed’), in which we explicitly *point* to a thing in order to accomplish the definition. Ostensive definitions are held to be the most basic form of “definition”, since in a very real sense neither symbols nor what we typically mean by the word ‘meanings’ are involved in the Definiens; rather, the Definiens is an Object, to which the Definiendum is made to *refer*.

Extensional definitions are not restricted to defining Objects, for we can give an Ostensive definition of a Feature as well: when describing a ball of a particular color, for instance, I could simply state that “When I say of a ball that it is ‘yellow’, I mean this color.” (at which time I point, for instance, to the skin of a banana). And this type of definition can be expanded in order to fully define physical objects in terms of all of their perceivable Features. We could, for instance, define the ball above as “this color (as I point to the banana) with this shape” (as I point to, say, an orange). In addition, this form of defining an Object can now be extended to the definition of a Kind; although here things are a bit more complicated, because Kinds are objects-once-removed, as it were, being “mental entities” composed of two or more Member-Objects. And although Objects themselves are, in one sense, compound entities (since they are composed of Features), the composition of an Object by its Features is different from the composition of a Kind by its Members. The physical Features of which *Objects* are compounded are *contiguous* with the Object itself (that is, the Features are *physical parts* of the Object), and thus we cannot point at an Object's Features without actually pointing at the Object. In contrast, Kinds are composed of Member-Objects rather than of Features, and these Members, as physical Objects, are *physically distinct* from (even if *formally analogous* to) the Kind itself (which of course is not actually a physical Object, but rather a collection of Objects). As a result of this complication, we could point to a Member-Object in order to attempt an Ostensive definition of the Kind, but—because we can see the Member-Object but cannot see the Kind—we could easily be misunderstood. To give a complete Ostensive definition of a Kind, then, we would have to point to each and every one of the Members of the Kind; but even this will only work for Kinds all of whose Member-Objects are present, a situation that does not hold for all (or even most) natural Kinds. Accordingly, when we attempt to define a Kind whose members are not present (for whatever reason), we are forced to use a different method, although it is still a type of Extensional definition. This new method, called definition by Enumeration, involves the *naming* of the complete physical extent of the Kind (that is, all of its Member-Objects). This method, then, is clearly not Ostensive, for we are not *pointing to the Referents* (the Members of the Kind), but rather *listing or enumerating the names* of the Member-Objects.

When we make this move from pointing to naming, as a means of defining, we are of course introducing an entirely new level of complexity into the process of definition. Not only can we do more with words than with gestures (such as pointing), we do not even need to be in the presence of that which we are naming. Enumerative definitions, thus, are much more common than are simple Ostensive definitions, and in fact they are used regularly. Whenever a teacher reads the names off of a roster in order to call roll in a classroom, for instance, he or she is using, at least in a manner of speaking, an Enumerative definition. Of course, Enumerative definitions do have their limitations, being useful for defining Kinds, and for collections in general (whether they are viewed as "classes" or not), but not for much else in our day-to-day lives. In mathematics, however, Enumerative definitions come into their own, for there they are seen as one of the two means of defining *mathematical classes*, the second means of defining being the other major form of definition mentioned above: Intentional definition. In order to give a full definition of a mathematical Class, then—for instance, the class {1,2,3,4}—we can take either the Enumerative approach and say that "By the class $\mathcal{C}$ I mean the class that consists of the numbers 1, 2, 3, 4.", thus defining $\mathcal{C}$ in terms of the *enumeration* of each of its Members, or we could take the Intentional approach and simply say that "By the class $\mathcal{C}$ I mean the class that consists of the first four positive numbers."

Clearly, the Intentional form of definition is closer to what most people would call the standard form of definition; and indeed intentional definitions make up the bulk of the definitions that are given in our dictionaries. All the same, we must acknowledge that the notion of a *standard definition*, particularly of the type found in a dictionary, is a fairly recent invention, as in fact are dictionaries themselves. Pre-historically (which literally means "before the advent of written language", a period that ended only about five thousand years ago) no means of recording definitions existed; never the less, natural languages were able to manage well enough without explicit definitions. In fact, although our need to know the significance of the words that we use was present then as now, for most of our cultural traditional the *usage* itself of a word or phrase was means enough to maintain such traditional "definitions". With the advent of writing, however, a method of storing definitions appeared, and before too long a standard form of definition—what we now call a *stipulation*—developed. This standard definition always takes a *particular* form and is thus called also a "formal definition". Among formal definitions are included a General Form—definition by Genus and Differences—and several, more detailed, Specific Forms: 1) Precising definitions, 2) Theoretical definitions, and 3) Operative definitions.

Taking these in order, the General definitions assumes that the symbol to be defined refers to an Object that is a member of a Kind or Class (and which may be a sub-Class), but which differs in some respect from other members of the Kind. The definition, then, is caste in terms of this hierarchy of types (a Kind and its Members), and accordingly is given the name of definition by Genus (the Latin word for 'family', which is a natural type of *Kind*) and Differences. An example of such a definition would be that of 'atom' as 'a body that has no parts'. Here the fact that an atom is a body shows that atoms are members of the *Genus* or Kind "material objects", while the statement that an atom has no components or parts marks its *Difference* from all other material objects. When forming these definitions in terms of Genus and Differences, several guiding principles or rules must be kept in mind (as listed in the Summary below). First, the definition should be in terms of what are called the essential attributes of the object to be defined. Second, the definition should be non-circular; that is, the word to be defined should not be used in the definition itself. Third, the definition should have an appropriate scope, which is to say that it should be neither to broad—covering too much, as it were—nor too narrow—covering too little. Fourth, the definition should avoid figurative language, or language that is vague and ambiguous in general. And finally, fifth, the definition should not be negative when it can be positive. Admittedly, of course, some words are naturally negative, and with these words negativity cannot possible be avoided. But when it can be avoided, it should be; a standard definition is expected to be a positive definition.

Next we come to the Specific definitions, in which a conscious attempt is made to sharpen the scope and focus of the definition. In Precising definitions, the most obvious type of "sharpening" definition, the significance of a symbol is modified in such a way that it reflects the special needs and interests those who are using the Precising definition. An example of a Precising definition would be that refinement in Science that led to the re-definition of a 'meter' as 'the distance light travels' in a given time; and in general the re-definition of many scientific units in the twentieth century. Moreover, the original definition of the meter (and, again, many of the scientific standard units) is itself an example of a Theoretical definition, in which a word is defined with respect to some scientific theory. The meter, in fact, was introduced by the French to help standardize the science of Physics, and its original definition was "one ten-millionth the distance from the North Pole to the Equator". Finally, Operative definitions are also commonly found in the sciences, and in these definitions there is always some operation (in the broadest sense of the term) that serves to determine the application of the defined symbol. A trivial example is found in the notion of a 'genius', but only when this term is used in the sense of 'achieving a particular score on an IQ test'; that is, if someone performs the operation that we call "taking the IQ test", and this someone receives a score above a certain number, then that person can be called "a genius".

To summarize, a *definition* is the specification, in the form of a stipulation, of the significance of a symbol. A stipulation is an insistence upon a particular contract; in a definition, this stipulation is the "drawing together" of the symbol and one of its two different forms of signification—1) the Referent, and 2) the Meaning. The symbol is called the "vehicle" of the significance, which is itself called the "rider" of the vehicle.

A Summary of the Properties and Forms of Definition:

Referent ⟵ Symbol ⟶ Meaning

Perception of Objects (Sensory)	Conception of Relations (Linguistic)
Extensional Definitions: ≈ *Denotation* (Literal Significance)	*Intentional Definitions* ≈ *Connotation* (Figurative Significance)
a) Ostensive: Definition by Pointing b) Enumerative: Definition by Naming	a) Traditional: Definition by Usage b) Formal: Definition by Stipulation b1) Genus & Differences b2) Specific

Expanded Analysis of the Types of Meaning:

a) Traditional: Definition by Usage
- a1) Synonymy: "The same as x": "By 'analogous' I mean the same as 'similar'."
- a2) Etymology: "Derives from x": "The word 'analogous' is derived from 'logos'."

b) Formal: Definition by Stipulation

b1) Genus and Differences:

‘Genus’ means ‘Kind’, ‘Differences’ refers to *others* of the same kind.

b1a) Essential Attributes: Refers to the necessary properties of the definiendum

b1b) Non-Circular: If the definiens contains the definiendum, this is circular

b1c) Appropriate Scope: Definiens entail only what is entailed by the Definienda

b1d) Non-Figurative: Must not use Figures of Speech as Denotative definiens

b1e) Non-Negative: Must define what the definiendum is, not what it is not

b2) Specific types of Definition:

b2a) Precising: The new definiens is less ambiguous than the current definiens

b2b) Theoretical: The definiendum is defined in terms of some theory

b2c) Operative: The definiendum is defined with respect to a specific operation

The Uses of Argument — *Stephen Toulmin*

In an attempt to clarify and thereby (perhaps) resolve these serious shortcomings of the material Logics, the English logician Stephen Toulmin introduced, in 1958, what is perhaps one of the most comprehensive analyses of the overall structure of an argument. As we see below, Toulmin used a different set of terms than what we have been relying upon to illustrate his ideas.

The Present Nomenclature:	*Toulmin’s Nomenclature*:
The Premises => The Conclusion	(The Data + The Warrant) => The Claim

In fact Toulmin has already expanded, as it were, the structure of what we here have called the Reasons or Premises, for he includes the two notions of Data and a Warrant where we have only one term—the Premises. Nevertheless, it should be fairly apparent that the structure we use is analogous to that given by Toulmin, for Toulmin’s Data are specific instances that are taken from the Real World and bound together, as it were, by the Warrant or Reason that connects the Data to the Claim/Thesis. At the same time, Toulmin does not stop here, but goes on to give a much more complete analysis of argumentative structure. As we can see from the expanded form given below, then, the Warrant can be shored up, in a manner of speaking, by additional “evidence” that sits be hind the Warrant, as it were, and is thus called the Backing. In addition, we may be aware of certain criticisms that might effect our argument, and so Toulmin includes the possibility of a Rebuttal offered by the argument, against these Critiques. And finally, since the considerations of material Logics have already revealed the possibility that the

Claim does not follow from the argument in an *absolute* manner, but rather may in fact be only *probabilistic*, Toulmin's structure includes the possibility (or perhaps necessity) of using a qualifying statement—called by Toulmin the Qualifier.

Toulmin's Expanded Logical Structure (1st Level):

[The Data + The Warrant + The Rebuttal – The Qualifier] > The Claim
(*Backing*) [*Critique*] ("*Probably*")

Of course, an actual argument need not include every one of these components; for deductive arguments certainly do not require a Qualifier, and even inductive arguments may not be faced with any Critiques or require any Backing. Nevertheless, most arguments in Natural or Material Logic will benefit from including all of Toulmin's components. For example, let us assume that you would like to go to the movies with your friends, but your parents are reluctant to let you see the particular movie that happens to be playing. As Data for your argument, you might inform your parents that,

Toulmin's Expanded Logical Structure (2nd Level):

Evidence:
Datum$_1$
Datum$_2$
Datum$_3$ } + The Warrant + The Rebuttal – The Qualifier > The Claim
Datum$_4$ ↑ [*Critique*] "*Probably*"
Etc.
Backing1, Backing2, etc.

for instance, your friend John is going to this movie, as are your friends Betty and Alice. With respect to Toulmin's analysis, these Data are called Evidence, and would be listed as Datum$_1$, Datum$_2$, and Datum$_3$ in a structural analysis of this argument illustrated above). The Warrant, then, might be the fact that you are presently not on restriction for anything, which would at least *seem* to warrant your being allowed to go to the movies. At the same time, it might be that your parents are aware that you do not have any money at this time, and they could levy this criticism against your argument. Fortunately for you, however, it just so happens that your friend John owes you ten dollars, and so you could counter your parents' Critique with this point, as a Rebuttal to their criticism. Your argument would then require the Qualifier that "John will probably pay me what he owes me, and I thus will have the funds to go to the movies." Of course, you are still faced with the problem that your parents do not want you to see this particular movie, but in this case you could offer as Backing the fact that originally your friends' parents were reluctant as well, but they were eventually convinced that the movie is not inappropriate. Unfortunately, even this Backing may not convince your parents that you should be allowed to go see this movie; but at least you will have provided them with a complete argument as far as Stephen Toulmin is concerned.

As an example of an material argument, consider the following thesis: "The Earth is shaped like a ball."; and keep in mind, this thesis expresses the Conclusion for which we are arguing. As a good example of a Premise for this thesis, consider the observable fact that, when the Earth's shadow falls on the face of the Moon during a lunar eclipse, the edge of the shadow is clearly curved. What we want to know is, "What material and formal relations, *what Logical connections*, exist between this Premise and the Conclusion and thus allow us to make this argument?" Of course, at this point in our studies we are not yet in a position to fully appreciate this question, let alone answer it. And so for now we will simply point out that: 1) we believe that a material relation holds, because we know that, here on Earth at any rate, a curved shadow is cast only by a round (perhaps spherical) material object, such as a ball; and 2) we believe that a formal relation holds, because a difference in size and location should make no difference between objects of a given shape and their shadows. That is, even though the argument is not talking about the shadow of a relatively small ball here on Earth but rather about *extremely large* spheres—the Earth itself, and the Sun and the Moon—sitting out in space; still, these differences should not effect the underlying formal structure. Using these two relations, then—the formal and the material—we can assume that the way shadows are cast *in space* by very *large material objects* should be no different from the way that shadows are cast here *on Earth* using a comparatively *small material object*: a ball. And consequently, we can conclude that the Earth is indeed shaped like a ball.

Obviously, this example is rather trivial, especially when compared to scientific arguments about the structure of Reality, for instance, or to moralistic arguments about crime and punishment. Nevertheless, even this trivial example can serve to illustrate the richer argumentative structure revealed by Toulmin's analysis.

Fallacies—Logical and Rhetorical Failures in Argumentation

Given the complex structure of argumentation, as revealed by Toulmin's analysis, it becomes obvious that a logical argument can fail in many ways. The Evidence, for instance, may turn out to be false; or it might be true, but irrelevant to the argument. Or the Warrant may not actually connect the Evidence logically to the Claim or Conclusion. And ultimately, material arguments are always contingent—hence the requirement of the Qualifier—and may thus turn out to be wrong. Accordingly, a systematic analysis of the different possible failures in the argument, known traditionally as Fallacies, has helped clarify our understanding of argumentation. In the following explanation of the so-called

Logical Fallacies, we shall rely upon Aristotle's analysis of the structure of Communication as our context of understanding.

The earliest acknowledgment (and the first analysis) of the Structure of Communication comes from Aristotle's text entitled the *Technics of Rhetoric*. In this particular text, Aristotle informs us that there are actually three forms of rhetorical persuasion—forms that the Greeks called Ethos, Logos, and Pathos—and as Aristotle's analysis in his text demonstrates, these three forms of persuasion derive directly from the three components of Communication, as is shown below in Figure 3-2.[10] In the first of these forms of persuasion—that of Ethos—we learn that discourse can be made more persuasive by focusing upon the ethical or moral character of the Speaker. For, if the speaker can convince us that he or she deserves to be *believed* because of his or her wonderful ethical character, we are more likely to believe what he or she says. This particular rhetorical tactic, Aristotle's Ethos, is common among politicians, who use it either in a positive manner by pointing out some of the wonderful things they have done for us in the past, or in a negative manner by pointing out the low moral character of their opponents (a tactic appropriately, and of course figuratively, called mud-slinging). In the second form of persuasion, that of Pathos, the underlying persuasive appeal focuses upon the emotions of the Audience, a tactic that, as Aristotle noted, is made all the more affective by the use of illustrations whose content can wrench our emotions. This pathetic appeal, as it is known, is often employed by television advertisements, which tend to overtly display an overwhelming series of attractive lifestyles that might appeal to our emotions while displaying the actual product either covertly or only at the end of the commercial. Finally, in the third of Aristotle's forms of persuasion, which he called Logos, we focus our attempts to communicate upon the actual logical structure of the argument itself, a tactic that is supposedly the sole tactic of the sciences.

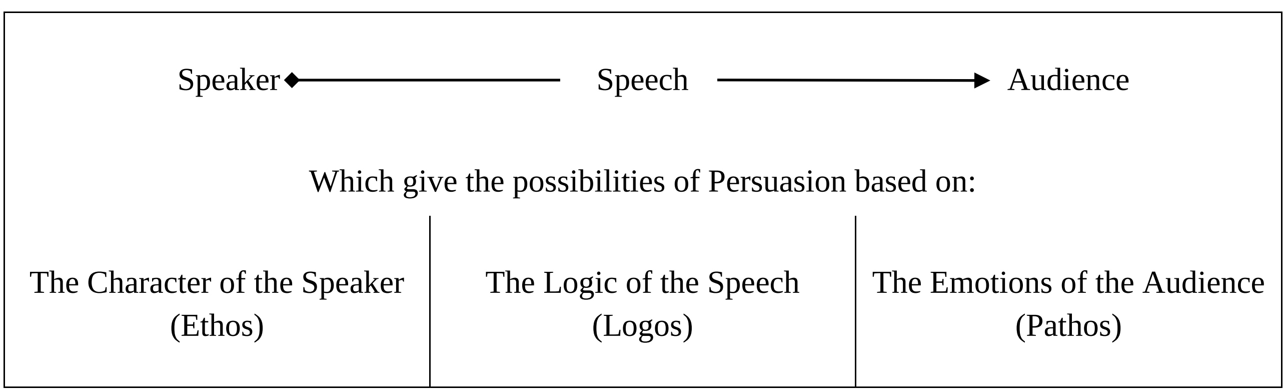


Figure 3-2. The Structure of Communication and Aristotle's Three Forms of Persuasion

With this understanding of Aristotle's Rhetoric in hand, we may now take our brief survey of what are commonly called the Logical Fallacies. These fallacies are forms of argumentation that appear to be logical on the surface, but can in fact be seen to be illogical (in one way or another) upon closer inspection. A list of many of the most common fallacies is given in Appendix Two, and although no examples have been provided there for the fallacies, the fallacies themselves are common knowledge and can easily be researched further. Below, however, you will find both definitions and examples (for the most part) of some of the more pertinent Logical Fallacies.

The Appeal to an Inappropriate Authority (Argument ad Verecundiam):
Using an expert in one field as evidence in another field:
"Look how smart Einstein was, and he believed in God, so God must exist."

The Attack on the Speaker (Argument ad Hominem):
Attacking the character of the speaker:
"You can't believe what Bill Clinton says, considering his lack of moral fiber."

The Appeal to Force (Argument ad Baculum):
Using the threat of violence against the audience:
"You should get your trash off my yard, or I'll send me wife to straighten you out."

The Appeal to Misery (Argument ad Misericordiam):
Implying or suggesting that the audience will be miserable:
"If you don't go out on a date with me, you'll be sorry for the rest of your life."

Amphiboly:
Using syntactic or semantic ambiguity that occurs because of slovenly grammar:
"The man beat the fire out with his wife."

The Accent Fallacy:
Using semantic ambiguity that occurs because of an error in (or lack of) emphasis:
"Jefferson meant to say "All men are *created* equal," not "All men are created *equal*."

Equivocation:
Using one word in two ways in to imply the first meaning by means of the second:
"All bakers make more dough than they do bread, so all bakers must be rich."

The Irrelevant Proof:
Proving something other than the original claim:
"I know astrology is valid, it says good things about me." (You proved you're an idiot.)

The Negative Proof (The Argument from Ignorance):
Using the absence of evidence, or negative evidence, as evidence of absence:
"There is no objective evidence for the existence of God, therefore God does not exist."

The Circular Proof (Begging the Question):
Assuming the conclusion in the premises:
"Ten reasons to believe that the Bible is God's word: 1) the Bible says so."

The Prevalent Proof:
Using mass-opinion as evidence:
"God must exist, because so many people in the world believe in God."

The After-This therefore Because-of-This Fallacy (Post Hoc, Propter Hoc):
Assuming that if B follows A temporally, then B follows *from* A causally:
"Since the leaves fall after geese go south, then the geese must make the leaves fall."

The With-This therefore Because-of-This Fallacy (Cum Hoc, Propter Hoc):
Assuming that if two things occur together then one is the cause of the other:
"Since the wind blows almost always when the Sun rises, the Sun causes the wind."

The Before-This therefore Because-of-This Fallacy (Pro Hoc, Propter Hoc):
Placing the effect temporally before the cause:
"The leaves are falling from the trees, so the weather will soon start to get colder."

The Composition Fallacy:
Inferring from a property of a group to a property of a member of the group:
"China eats more rice than America, so each Chinese eats more than each American."

The Division Fallacy:
Inferring from a property of a member of a group to a property of the group:
"Electrons are basic particles in atoms, so atoms must also be basic."

Many of these fallacies are straightforward enough, as for instance the fallacies that involve the notion of Causality—such as the "After-this therefore Because-of-This" fallacy—for these are Logical failures *strictly speaking*: they confuse the Logic of Time with the Logic of Causality. This class of Logical Fallacies are either shortcomings of—or downright failures in—the Logical relationships involved. Other fallacies, however, are not, strictly speaking, failures in Logic *per se*, but rather are attempts to skirt Logic in favor of what can and should be legitimate Rhetorical tactics. When these Rhetorical tactics are not employed properly, however, they actually work against the logic of the argument rather than in favor of it. And in contrast to the strictly-Logical fallacies, this class of Logical Fallacies cannot truly be understood except by means of the Structure of Communication.

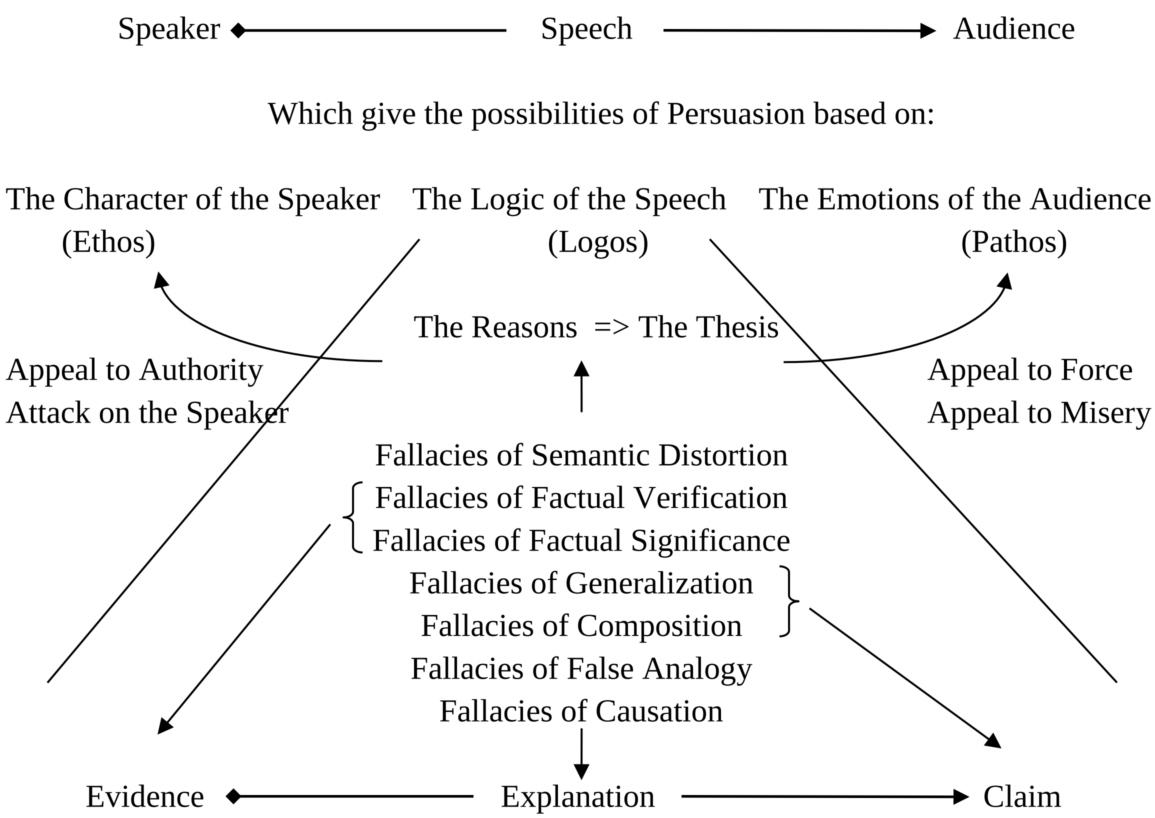


Figure 3-3. Logical Fallacies and the Structure of Communication

apparent, however, is that Aristotle's Logos is intended to entail the whole of the logical apparatus, and thus Logos entails all of the strictly-Logical fallacies. In contrast, many of the type of fallacies given above *do not* involve Logic, strictly speaking, and accordingly these fallacies should really be called Rhetorical Fallacies rather than Logical Fallacies—for they concern only the rhetorical tactics of Ethos and Pathos, and do not involve the tactic of Logos, at all. Accordingly, as illustrated in Figure 3-3, above, all strictly-Logical fallacies—such as Begging the Question or Proof by Analogy—are included in the middle of the lower section of the diagram, beneath the Logos heading. Conversely, we may make a legitimate *rhetorical* appeal to the character of the Speaker (Ethos)—and such appeals are classed together under the heading of the Ethical Appeal The Appeal to Authority, for instance, which appeal should be persuasive thanks, at the very least, to the Speaker's authoritative knowledge of the subject of the argument, is a type of Ethical Appeal. At the same time, if the Speaker does not in fact have the authoritative knowledge he or she claims to have, but rather is merely intimating that he or she does, then we are ultimately making an Appeal to an Inappropriate Authority, and this is a fallacious form of an otherwise legitimate rhetorical tactic (and is thus, as has been pointed out, a Rhetorical Fallacy). Similarly, we may skirt the logic of the message itself by going outside of the Logos-area (in Figure 3-3) in the direction of the Audience rather than of the Author. And again, if we do this in an appropriate manner, we are merely employing one or another legitimate rhetorical device—for instance, if we make an appeal to the emotions of the Audience, such as in an Appeal to Misery. There is certainly nothing wrong, rhetorically speaking, with stirring the emotions of your audience in order to persuade them to accept your argument. However, if we appeal to our Audience's emotions because we know that the logic of our argument is faulty and we wish to dissemble this fact by the Appeal to Misery, then we are again skirting Logic and committing a rhetorical fallacy. And of course the Appeal to Force is never an appropriate *Logical* tactic. In fact, the Appeal to Force would seem to be a doubly-fallacious rhetorical tactic, being both a militant appeal to the Speaker's strength (and thus to his or her character)—because in effect it is the speaker who is forcing us to accept his or her argument—and at the same time an aggressive appeal to the safety of the audience. Obviously, neither of these aspects of the Appeal to Force has anything whatsoever to do with Logic.

There are many other Logical Fallacies that have not been discussed here; unfortunately, the nature of our studies does not allow of a further treatment of this subject. The present introductory discussion, however, is comprehensive enough for our purposes, and accordingly we have discussed some of the more pertinent fallacies of both the Logical and Rhetorical type.

Material Logics — The Logics of Discovery

The time has come, at long last, to directly address the topic of the Logics of Discovery. These logics are classified as being "of Discovery" because they are the logical inferences that human use to discover new ideas about causal and analogical relations among Objects in the World. In their fundamental and most natural forms, they are basic methods of the workings of the human mind—that is, they provide much of the basic psychology that produces our natural understanding of the World. In their intellectually mature and "rigorous" forms, the provided the fundamental framework for the scientific understanding of the World, as well as the potential for the discovery, as we have mentioned, of new ideas that may be worthy of scientific investigation.

In terms of the Theory of Knowledge expressed earlier in the Three Stages of Belief, the Logics of Discovery produce Sound Belief. As you may recall, Sound Belief is *contingent* knowledge of the World based upon a logical understanding of Causality and Material (as opposed to Formal) Analogy, with a bit of Natural Language "deduction" thrown in, in the form of Semantic Analysis. This type of analysis, which uses the traditional meanings of words as indicative of "necessary" Logical relations between the Objects and Classes referred to by the words, is what passes for Deduction in Natural Languages. Unfortunately, it is ultimately unreliable (and in fact not actually Deduction), since it relies upon not only the *meaning* of the Logical Symbols (which are the words of our languages) but also allows for the referents of the words to help determine Formal relations. In other words, it allows material relations to be considered in what should, by definition, be a purely formal endeavor. Accordingly, the use of Semantic Analysis is risky business and should be avoided in Science and Philosophy.[11]

The Logics of Discovery — *Sound Belief, The Logic of Contingent Truth:*

Turning, then to the Logics of Causality and Material Analogy—the Logics of Abduction and Adduction, and the Logic of Induction, respectively—we find a Logical approach to these material processes and structures. In particular, Abduction and Adduction are two forms of logical analysis of the process of Causality, in which Abduction allows us to *surmise* a Cause of some material situation that we take to be an Effect of something; while Adduction allows us to *predict* the Effect of a Cause that would occur if we actually produce the Cause. And Induction, the Logic of Material Analogy, is the Logic by which we investigate the ways in which things are similar or analogous to each other, from which information we *surmise* the existence of material Classes, or of General Laws of Nature, our so-called Inductive Generalizations.

What is of note here are the particular words used to describe the actual essence of each of these Logics: Abduction and Induction *surmise*, while Adduction *predicts*. But a surmise is, by definition, a *guess*, it is an inference that lacks sufficient evidence; and predictions are pretty much the same thing. Admittedly, we often feel fairly certain about our predictions; for instance, few scientists would feel sure enough to insist that their prediction that, say, the sun will rise tomorrow, is pretty much guaranteed. But of course, it is not; there is always the possibility that some unknown material situation will interfere, and the prediction will turn out wrong. In other words, even predictions are guesses; and so Adduction, along with Abduction and Induction, are types of Logic that involve some form of hypothesization. Accordingly, these Logics of Discovery allows us to hypothesize contingent ideas about the Material World that constitute our Sound Belief as potential candidates for Deductive Justification. In summary, then, the Logics of Discovery are types of:

Hypothesization: Inferring a Theory from Observations and Experience, in the form of:

a) *Abduction*: Hypothesizing a *Cause* (in the Past) of a current situation (the *Effect*)

b) *Adduction*: Hypothesizing the (Future) *Effect* of a current situation, the *Cause*

c) *Induction*: Hypothesizing a *Generalization* from a set of *Analogous* Observations

Turning now to the details of these Material Logics, we first note that, as most standard introductory presentations of Logic clearly indicate, Natural Logic relies upon two main relationships, those of Causality and Analogy, for its understanding of the World. As we shall see in the rest of the chapter, these relationships have had a long life in the history of human understanding; and ultimately they are grounded in the more rigorous notions of Contiguity and Isomorphism, as discussed in Chapter One.[12] However, Causality constitutes but one form of Contiguity, and there are in fact other important contiguous relations—other forms of Contiguity—with which Science deals, such as the relationship of Part to Whole. And Analogy, too, as we traditionally understand this term, is but one way in which we can compare the Isomorphism of different systems. Mathematical *models*, for instance, which modern-day scientists use to help them understand what they are investigating, are actually types of Analogy and thus are ultimately forms of Isomorphism. To begin our explanation of the Logics of Discovery, then, we shall start with the Logics of Causality, after which we shall address the Logic of Material Analogy.

Abduction and Adduction — The Logics of Causality:

In order to understand the Logics of Causality, we must first of course be familiar with the basic structure of the natural process that we call Causality. We shall start with a very basic representation of Causality, one familiar from our everyday experience with Causes and Effects. In particular, we shall use the letter C to represent a Circumstance in the material world that we take to be the Cause, and the letter E to represent the Event in the material world that we take to be the Effect. The material relation of Causality, then, will be represented by an arrow; and the complete representation is thus as simple as:

$$C \rightarrow E$$

which should, of course, be read as "C is the Cause of the Effect, E"; or "E is the Effect of the Cause, C." Soon enough, we will analyze this structure in much more detail, discussing at length the various concepts involved. For the time being, however, we shall say simply that the Causality that we have in mind here is Material Causality (sometimes called Efficient Causality) such that some material circumstance C physically exists in such a way that, *in time,* it produces a material event E, different from and subsequent to the original circumstance.

The Logics of this type of material structure involve, as has been mentioned, surmising a Cause for some observed Effect—the Logic of Abduction; and predicting an Effect of some produced Cause—the Logic of Adduction. Starting with Abduction, we define *Abduction* as "Hypothesizing a Circumstance that existed in the Past as the Cause of an Event the exists currently, called the Effect." In other words, to Abduce a Cause C from an Effect E is to *surmise* that C must have been the circumstance in the past that lead to the current event E we wish to explain, because if C were the case, then E would follow as a matter of course. Accordingly, when we Abduce a Cause we are attempting to explain a *Particular* Event *after the fact*, and we do so by reaching back into the past and "abducting" a particular past circumstance as the Cause. Consequently, we say that Abduction is *surmising a Particular Cause,* A Posteriori (which is Latin for "after"). The following are two simple examples of Abductive Logic:

Example #1:	*Grounds:*	*Logical Form:*
This barn-cow is pregnant.	Observation	1. $\exists!(c) \mid P(c)$
If a bull snuck in, then this cow could get pregnant.	Causal Hypothesis	2. $[\exists!(b) \mid C(b) \rightarrow P(c)] > P(c)$
A bull snuck in the barn.	Abductive Conclusion	3. $C(b) \rightarrow P(c)$

Example #2:	*Grounds:*	*Logical Form:*
My neighborhood is all wet.	Observation	1. $\exists!(n) \mid W(n)$
If it rained last night, then my neighborhood would be wet.	Causal Hypothesis	2. $[\exists!(r) \mid C(r) \rightarrow W(n)] > W(n)$
"It rained last night.	Abductive Conclusion	3. $C(f) \rightarrow E(d)$

As we see from the examples given above, Abductive reasoning begins with an Observation of the World. This is necessary, of course, because Abductive Logic is reasoning about the Cause of a current material situation. Next comes the Causal Hypothesis: X causes Y, and so if X happened Y would follow as a matter of course; and for this reason alone Abductive Logic is said to be a type of Hypothesization. And finally, the Conclusion of the argument is called Abductive in order to underscore the fact that our Logic here is Abductive. When we put all of this together into a statement that summarizes this process, we have what we may call the *Abductive Rule*:

If E is the Effect of Cause C, and E happened, then C must have happened before.

Examples of Abductive Reasoning

Causality being the powerful force for scientific understanding and technological productivity that it is, the utility of Abductive Logic is obvious. Accordingly, we find numerous instances of the use of Abduction in Science. A wonderful example comes from the late Pleistocene era, some ten thousand years ago, in North America. As is well known, many large mammals once roamed the area, only to disappear at just about this time. One of the most amazing of these large mammals was the Short-Faced Bear, a now-extinct species that stood six feet high on all fours, and thirteen feet high standing upright. But height is not the only big thing about the Short-Faced Bear; it has a huge nose and a massive nasal cavity, allowing for an unimaginable number of olfactory nerves. As you might guess, it could smell things at very long distances—up to six miles away; and its great height upright gave it access to scents that smaller animals could not detect. A nose this good could be an aid in hunting, and so you might think these bears hunted; as it turns out, however (and we shall see this shortly), the Short-Faced Bear could not have been a hunter. Rather, the belief is that the Short-Faced Bear was a scavenger. In part, the justification for this belief is a bit of Abductive Logic. If the Short-Faced Bear were a scavenger, then its huge nose and powerful olfactory sense would follow as a matter of course, allowing it to detect the scent of carrion. Therefore, the Short-Face Bear was (probably) a scavenger.

A second and last example of Abductive reasoning from science comes from the science of Cosmology and the theory of the creation of the universe. The Standard Model of cosmological creation, popularly known as the Big Bang Theory, attempts to describe and explain the origin of the universe. In the process, the theory posits that, not long after the Big Bang, matter came into existence; and as the universe expanded from the initial "bang", this matter was distributed around the universe. And as we look around the universe today, we can still see much of this matter, as stars and galaxies distributed more or less randomly around. The Big Bang Theory thus describes and explains even the matter in the universe as we see it today. Or at least, the theory *should* describe and explain the universe. Unfortunately, the density and distribution of matter as predicted by the Standard Model did not match what we actually see; in other words, the theory was wrong! Fortunately, scientists seem never to be at a loss for ideas, and on of them suggested that a simple ideas could fix the theory. As we all know, the universe is expanding; and our belief is that it has been expanding ever since the Big Bang. However, the *speed* of the expansion is not an absolutely fixed speed; in fact, we believe these days that the expansion is speeding up. Consequently, you might think that in the past the expansion was slower; and in part you would be correct. But the idea that saved the Big-Bang Theory actually says that, right after the Big-Bang started the expansion, it actually speed up at an unimaginable rate, but only for a brief moment. This brief super-expansion is known as Inflation; and with this ideas added to the Big-Bang Theory, it was redeemed. In summary, then, if the Inflation occurred, then the matter density distribution we see today would follow as a matter of course. Therefore, Inflation occurred.

Of course, Science is not the only intellectual pursuit that uses Abductive Logic, and in fact Abductive reasoning is among our basic methods of thinking about the world. As a result, whenever we try to explain the World we will most likely us some form of Abduction. In mythological narrative, for example, which includes ideas that passed for our earliest explanations of the World, Abductive reasoning abounds. Most Creation myths are classic examples. These stories are our first attempts at understanding and explaining the World, although (and perhaps, as a result) they are more or less wild guesses based upon little knowledge of how things in the World really are. Never the less, Creation myths do attempt to explain how the world known to the narrators came into being; and as such—that is, by looking at the World *now* and *guessing* at what in the past *caused* it to be this way—these myths are using Abductive reasoning. And in general the basic religious attitude of our mythopoetic ancestors worked this way: the World we see now is ordered. If God created the World, then the order in the World would be a matter or course. Thus, God created the World.

A second example from our mythological past comes in the form of what are known as Etiological Myths: myths that explain the cause (in Greek, 'etios') of some natural situation. For instance, one such myth involves a world-wide flood (there are such myths around the globe), which flooded the lowlands and forced all living creatures uphill to the mountain tops. Unfortunately for the raccoon, however, its tail was hanging down and as the floodwaters rose they submerged and stained the raccoons tail, leaving the familiar rings that we see today.

The Abductive Fallacy

Earlier in the chapter we learned about different types of fallacies, ways of thinking that sound reasonable but actually are not. And the two preceding examples, taken from mythology, are obvious examples of fallacious reasoning. Admittedly, the World may have been created; but more than likely this was not by means of God riding in a canoe and sending different animals down into the depths of the waters to see who could bring up enough mud to create the island Earth, as many myths purport. And the raccoon's tail did not get colored by the rising waters of a flood. Rather, Science has given us other explanations of what caused these things; and we accept these because scientists are constantly checking to see if their Abductive reasonings are justified.

Unfortunately for Science, there is no guarantee that any instance of Abductive reasoning is correct: if you do not witness the cause of something, then there is always a chance that, if you try to guess what the cause was, you will be wrong. This is the Abductive Fallacy, and it has been a pitfall to humanity ever since we started wondering about the causes of things in the World. It's saving grace, however, is that it is avoidable—we are often correct about our assumptions of causes—as the marriage of modern Science and technology has evinced. Science tries to determine the causes of things, and technology uses those causes to produce the effects that we expect from our scientific experience. As we have just learned, the first is what we call Abductive Logic; as it turns out, the second is the other type of Logic of Causality: Adductive Logic.

Adductive Logic

Although Adductive Logic—predicting an Effect for a certain Cause—is the heart of technological production, it is also of great importance in scientific reasoning. For, just as with Abductive Logic, with Adductive Logic we can discover new ideas that are important for our understanding of how things work. And, again like Abductive Logic, we define *Adduction* as "Hypothesizing an Event to occur in the future as the Effect of a current Circumstance that we produce as the Cause". In other words, to Adduce an Effect E from a Cause C is to *predict* that if C were to be the case then E would follow as a matter of course. Thus, when we Adduce and Effect we are attempting to *Universally* predict an Event *before the fact*. Consequently, we say that Adduction is *predicting a Universal Effect,* A Priori (which is Latin for "before"). The following are two simple examples of Adductive Logic:

Example #1:	*Grounds:*	*Logical Form:*
Bulls can make Cows pregnant.	Experience	1. $C_1 \rightarrow E$
If we put bull-seed in a cow, then we can make cows pregnant.	Causal Hypothesis	2. $C_2 \approx C_1 / C_1 <> C_2$
We can make cows pregnant.	Adductive Conclusion	3. $C_2 \rightarrow E$

Example #2:	*Grounds:*	*Logical Form:*
Nature makes water into ice.	Experience	1. $C_1 \rightarrow E$
If we mimic nature, then we can turn water into ice.	Causal Hypothesis	2. $C_2 \approx C_1 / C_1 < > C_2$
"We can make ice."		3. $C_2 \rightarrow E$

As we can see, Adductive reasoning begins with our Experience of the World. And again, this is necessary, because Adductive Logic is reasoning about the Effect of a current material situation. Next, again (as with Abductive Logic), comes the Causal Hypothesis: X causes Y, and so if we make X happen Y should follow as a matter of course; and for this reason alone Adductive Logic is also said to be a type of Hypothesization. And finally, the Conclusion of the argument is called Adductive in order to underscore the fact that our Logic here is Adductive. When we put all of this together into a statement that summarizes this process, we have what we may call the *Adductive Rule*:

If C is the Cause of he Effect E, and we make C happen, then E will happen after.

Examples of Adductive Reasoning:

As we have mentioned, Adductive Logic lies at the heart of technological production—in particular, every act of invention is an instance of Adductive reasoning. And not surprisingly, perhaps, Adductive reasoning is often assisted (and preceded) by a bit of Abductive reasoning, which is often necessary in order to determine the Cause of something: before you can mimic the Cause, you have to know it. Similarly, in Science these two Logics of Causality often go hand-in-hand. We learned from our Abductive Logic, for example, that the Short-Faced Bear is very likely not a predator, but rather a scavenger. And this belief is derived from the great size and complexity of the animals olfactory system: it could smell a dead carcass six miles away. But Adductive Logic, as well, has something to add to the evidence that these Short-Faced Bears were not hunters.

Adductive Logic predicts an Effect for a given cause. As a result, for example, if I predict that light without heat (relatively speaking) will appear if I produce the appropriate circumstances, this is an instance of Adductive Logic, and the result is the electric light bulb. With respect to the Short-Faced Bear's predatory habits (or the lack thereof), we begin with the understanding that large predators must make high-speed turns while chasing prey. But the Short-Faced Bear's fore-leg bones could not have withstood a high-speed turn, because the bones are fragile and the weight of the bear so great that as a result the leg-bones would shatter. More specifically, the results predicted by reasoning adductively about the strength of the leg-bones and the force on those bones from the animals speed as the legs are planted to make a high-speed turn argue against a hunting predator. Thus, the Short-Faced Bear was not a predator, but rather a scavenger.

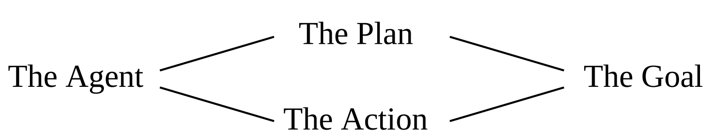
The Logics of Causality have been a powerful force in the history of Science, allowing us to discover possible causes of different aspects of the World, as well as to use our understanding of those causes to forward the efforts of technology. But the Abductive Fallacy is always a possible pitfall, and even the potential for testing newly discovered causal hypotheses by Adduction cannot guarantee that our Abductive discoveries are correct. In order to avoid error, then, with respect to Causal Logics, we need rigorous methods for investigating and understanding the causal relationship in its various forms.

Causality — Aspects of Contiguity

The development of the notion of Causality—of the belief that one event, called the Cause, can produce another event, called the Effect—was a tactic of survival. In our lives, we are constantly confronted with things and situations that can either enhance our lives or, quite to our detriment, can diminish or actually put an end to our lives. And naturally enough, we wish in general to take advantage of those things that can enhance our lives, and avoid those things that can diminish it. One way to do this is to look at these things as if they were products of earlier things, events, or processes—that is, to see things as Effects of Causes. In this way we can begin to get a grip, as it were, on the causal processes that produce the things we like and dislike, and thereby we can perhaps contribute to the production of those things we do like, and at the same time avoid or prohibit what we do not like. If we could do this, we would surely enhance the chances of our survival, and would probably even enjoy our lives more. Still, knowing why we need to understand Causality and actually understanding the productive processes involved are not the same thing, apart perhaps from the fact that we know that some sort of productive process is involved. So we need to look a bit closer at these productive processes, and for that purpose a natural example of Causality may be of help.

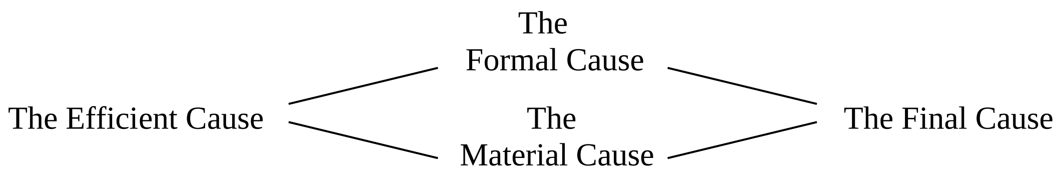
Consider, then, the causes of a wildfire (in a very simplified account, of course). To begin with, we know that we cannot have a wildfire without something to burn; thus, in one sense the presence of some grass, say, is in part necessary for a wildfire. The grass, however, is not really a cause of the wildfire, for grass can grow for years without burning; and when it does burn it constitutes the *material* of the fire—the fuel—rather than a cause of it. But we want to know why grass sometimes *does* catch fire. One factor, of course, would be the dryness of the grass, which for the most part is caused by the ambient temperature of the air being dry and warm over an extended period of time. In addition, if there are fairly brisk winds blowing, these could help fan and fuel the fire. But these factors alone cannot be all of the causes of a wildfire, because we know that for the most part fires do not just burst into flames for no reason. Rather, we need a spark of some kind to kindle the fire. For the sake of simplicity in our example, then, will we assume that these four conditions—dry grass; warm, dry air; winds; and a spark—are all that are needed to cause a wildfire. In this case, we say that each of the conditions individually is what we call a necessary condition for the wildfire, because each *must* be present in order for the wildfire to occur. But none of these conditions alone is sufficient, because each by itself is not enough to cause a wildfire. Of course, the spark can certainly ignite the grass, but if the grass is not appropriately dry it will not kindle; and even if it does, the fire will not spread fast enough to be a wildfire without warm, dry winds. Consequently, what constitutes the sufficient condition for a wildfire—the Sufficient Cause, that is, of the wildfire—is in fact a constellation of all of the *necessary* causes occurring together. And generally speaking, in order for an Effect to follow from its Causes, it is usually sufficient that all the necessary conditions occur together.

As the extant documentation testifies, the first philosopher to turn his thoughts explicitly to the study of Causality in the sense explained above was the great Peripatetic philosopher, Aristotle. He formalized the subject, gave an historical account the ideas of earlier philosophers, and introduced the notion of what he called the Four Causes. Unfortunately, Aristotle's account of Causality is clouded by his peculiar metaphysical notions, and many of the specific details of his theory have been rendered suspect by subsequent scientific developments, particularly within the last two centuries. Never the less, much of what Aristotle has to say on the subject still bears some relevance to our modern accounts, and we may thus begin our study of Causality with his Four Causes. For this, we can borrow a notion that Aristotle relies upon in his *Nicomachean Ethics*: the notion that a human being is an *Agent*, a being capable of intelligent and free action. Aristotle assumes a particular relationship between the Agent and the End result that the Agent wishes to produce, as well as between the Action that produces the End and the mental Goal that guides the Action. Schematically, the situation may be represented as follows:



Notice that we have separated the Action from the Goal; the implication being that the Action (strictly speaking) is a physical process carried out upon Matter, and is thus Material, while the Goal involves the Agent's ideational process concerning the *form* of the End product, and is thus Formal. And these two concepts categorize all four of

Aristotle's causes, and in fact constitute two of them: the Material Cause and the Formal Cause. Of the remaining two causes, the Efficient Cause is, according to Aristotle, "the primary source of change", and above the role of "source of change" is clearly played by the Agent; the Agent here thus represents Aristotle's Efficient Cause. And Aristotle's Final Cause is nothing but the end to which the Action is driven, which here is clearly none other than the Goal of this whole process. Accordingly, Aristotle's Four Causes can be illustrated as follows:



One of the more *interesting* accounts of the nature of causality given in the early modern era is that given by Arthur Schopenhauer in his dissertation, *The Fourfold Root of the Principle of Sufficient Reason*. Admittedly, the terminology of this text is more than a bit obtuse, and again (as with Aristotle) Schopenhauer's peculiar metaphysics tends to complicate his explication of this issue. Never the less Schopenhauer's exposition of Causality is cogent and informative, and thus well worth the effort. Unfortunately, this is not the place for such an endeavor, and we must therefore pass over Schopenhauer with only a mere mention. Instead, we will turn to what is undoubtedly the most well-known early-modern account of Causality: that given by David Hume in his *A Treatise on Human Nature*. There Hume discusses at length what he considers to be the essential features of the notion of Causality, and the account is unparalleled in the history of Philosophy. Nevertheless, from our current point of view even Hume's account is not as complete as we might wish, coming as it did almost three hundred years ago, well before the greatest developments in modern science. For our purposes, then, we will conduct our own analysis of Causality, deriving our ideas, however (at least, initially) from Hume's account. At the same time, Hume was himself influenced by Francis Bacon's ideas about Science (in general) and his three Tables of Investigation (in particular); accordingly, we will start our explanation of Causality with the man we hold responsible for the modern empirical attitude in Science: Francis Bacon.

Causal Explanations and Explanations of Causality

The transition from Classical Science to Modern Science, which helped produce the modern World, was championed originally by one person: the great English philosopher Francis Bacon. Bacon alone seemed to understand that Greek Science had no "objective", so to speak, other than to describe and admire the grandeur of God's work.

For Bacon, in contrast, the true objective of Science is to give humans the power to change the World in ways that will make human life better. Consequently, Bacon demanded a more systematic analysis of the *methods* of science in terms of causal explanations, and he set out these ideas on method in his empirically oriented work *Novum Organum*.[13] Published in 1620, this groundbreaking publication established Bacon as a philosopher of the first rank, bringing him to the attention (and, for the most part, exposing him to the attacks) of Europe's greatest scientists and philosophers. Among the several revolutionary ideas contained in this text was Bacon's call for a new type of Logic (in fact, the title of the text—*Novum Organum*—means "new [logical] tool", a title derived from the traditional title of Aristotle's Logical works—the *Organon*). But Bacon also included his take on what has often been called the scientific method (although this is an extremely vague and contentious concept).

Bacon's ideas about how to collect data (which we now call capta) and organize these data to reveal the information they entail are embodied in what he called the Three Tables of Investigation, given below:

The Tables and Arrangements of Instances:

1) Tables of Essence and Presence: Instances in which a Nature [that is, a Property] is *present in unlike* Substances or Objects.

2) Tables of Deviation or Absence in Proximity: Instances in which a Nature [that is, a Property] is *not present in unlike* Substances.

3) Tables of Degrees or Comparisons: Instances in which a Nature [that is, a Property] *varies in a given* Substance or Body. Or instances in which a Nature [that is, a Property] *varies in different* Substances or Bodies.

These Tables provide verification that "where the Nature [Property] is present the Form will be present, where the Nature [Property] is absent the Form will be absent, and where the Nature [Property] varies quantitatively the Form will vary quantitatively. And on data thus arranged we may apply the inductive method, which requires Affirmation, Negation, and Variation. This is the first step or First Vintage: the Commencement of Interpretation, a tentative interpretation (that is, Hypothesis) which we use as a guide to the selection of further instances by controlled observation or to the production of instances by experimentation. The first of these tables, also known as the Rule of Presence, was intended to be "the assembling of all known instances of a phenomenon that agreed in having the same characteristic. For example, if the subject was heat . . . then the scientific investigator would have to study all known instances of warm 'bodies' . . . ." In addition to this affirmative or "positive" knowledge, however, we also need negative knowledge, and hence we must include the second table, the Table of Negations. For heat, this "would mean the investigation of such entities as the moon's rays and the blood of dead animals, which do not give forth heat." And finally, Bacon's third table, also known as the Rule of Differing Degrees, entails "the study of variations in different phenomena to see if there is any correlation between the various changes observed."

David Hume's Analysis of Causality

Bacon's Tables of Investigation are intended, as is obvious, to determine the presence or absence of the *properties* of objects (which properties Bacon calls "natures"), as opposed to the Causes of Effects. All the same, the language Bacon employs suggests that Causality is somehow involved in the situations which interest him. In particular, the relationship between "the Nature" or Property under investigation and "the Form", as Bacon calls it, has all the earmarks of a Cause and Effect relation. As I understand it, Bacon's *Form* refers to a *material form*—such as a molecule, or perhaps a chemical substance—that might serve as the material Cause of the Nature or Property, which would make the Nature the Effect. To use a bit of Abductive reasoning here, if this were the case (with Bacon's language), then the statements given above (to the effect that "where the Nature is present the Form will be present, where the Nature is absent the Form will be absent, and where the Nature varies . . . the Form will vary") would constitute an incipient analysis of Causality.

In a very real sense, then, Bacon's ideas about Natures and Forms foreshadow the rules of causal analysis developed by David Hume and J. S. Mill. Traditionally, these rules of causal analysis are attributed to Mill; but Hume clearly is responsible for the earliest development of these characteristics of Causality, having analyzed and discussed his scientific understanding of the properties of Causality in his earliest work, the *Treatise*. There, Hume's analysis of Causality is spread over several sections of Book I, and what we find there is an extremely cogent analysis of the main properties or characteristics of Causality. In addition, a summary of his analysis, entitled RULES BY WHICH TO JUDGE OF CAUSES AND EFFECTS, is given in given in Section XV of Book One, Part Three. Considering the brief and yet cogent nature of what the summary relates, we shall restrict ourselves to an analysis of Causation according to its pronouncements. In particular, Hume lists eight so-called Rules by which we are to understand Causality; but the first three Rules are those that, in effect, contain Hume's essential characteristics of Causation, while the remaining five Rules are tantamount to methods for determining the Cause of specific Effects. In Hume's account, Causation necessarily involves two main ideas, Contiguity and Priority (which latter we prefer to call Antecedence); as Hume informs us, only these two properties of Causation can be known directly from Experience. All other notions that we have historically connected with Causation are derived from Experience by Inference, according to Hume, rather than being directly perceived by us. In particular, Hume considers the notion of a “necessary connexion” between Causes and Effects as the primary characteristic of Causation, an ideas he expresses elsewhere as the Constant Union of the two components of Causation. This Necessary Connection, however, is not something that we directly perceive, even if only because we cannot see necessity, but must infer it. Never the less, given Hume’s remarks, we can unequivocally state that the essential properties of Causation are:

1. *Contiguity*: Causes and Effects must be *contiguous* in space and time.

2. *Antecedence*: The Cause must be *prior* to the Effect.

3. *Constant Union*: There must be a *constant union* between Cause and Effect, and this is the essential characteristic of the causal relation.

Our analysis of these characteristics will begin with the last of these three notions, the Constant Union of Cause and Effect. Hume also use the terminology of a Necessary Connection, which in the quote given above is expressed by means of the imperative “must”. If there “must” be a Constant Conjunction, then this Conjunction is a Necessary Connection. Traditionally, as Hume points out, the necessity involved in Hume’s account is often confused with the notion that every event *must* have a Cause. Hume is especially incisive, particularly in his criticism of this idea as it is found generally among philosophers of his day. Unfortunately for us, however, the main thrust of Hume’s criticism is aimed at the belief that “every *event* must have a cause”, and this notion, although admittedly critical at this early juncture of Philosophy and modern Science, is much less relevant at the present time, having been rendered so by current notions of Causality derived from Quantum Physics. In addition, the tenor of Hume’s discussion makes it clear that his notion of Contiguity is not equivalent to the way that we define ‘contiguity’ these days, the current definition having benefited, as is quite natural, from developments in Science and Philosophy that have occurred since Hume’s time. In order to proceed, then, with our analysis, we must supplement Hume’s analysis with the more modern versions of these two notions.

To begin then, the notion of causal Necessity is often explained in terms of the necessity of an Effect following from its Cause. In this sense, whenever a Cause is present it will sooner or later, but in any event *necessarily*, produce its Effect. Unfortunately for the belief, however, this is simply not the way Causes and Effects work in nature, as we have seen from the example of wildfires, and can see from yet another example: the disease called typhoid fever. The ultimate physical cause, as it were, of typhoid fever is a particular salmonella bacterium—a one-celled creature that, once it is introduced into a human body, can proliferate, causing the body to suffer from the disease. And this is a clear-cut case of causality with a contiguous—that is, a physical—

connection. At the same time, the mere presence of the bacterium in a body does not necessitate its effect—the disease itself—because other factors, such as the capacity of the particular immune system involved, are also relevant. For this reason, among others, we say that the cause of typhoid fever is a complex situation in which not only the bacterium, but the flies that might carry it and the immune system into which it is introduced also play significant roles. We could, then, say that the cause of typhoid fever is a three-step process in which 1) a fly is infected with the bacterium, 2) that fly deposits the bacterium on or near a human being, passing on the bacterium, and 3) the immune system of the human being is in such a state as to be unable to eliminate the bacterium, which then proliferates and infects the person with the disease. In any case, however, what we find is that no single one of these three factors necessitates the ultimate effect—the disease. And even more significantly, often enough the combination of all three of these factors does not lead to the infected person's suffering the symptoms of typhoid fever. Extenuating circumstances could easily prohibit the eventuation of the Effect—that is, the infected person could be killed, for instance, in an automobile accident before the disease develops. Even barring this contingency, however, some people may be capable of carrying the bacterium without ever developing the disease; Mary Mallon, in fact, who is known as Typhoid Mary, is believed to have infected several hundreds of people in New Your City in 1907, although she never contracted the symptoms herself. As a result, then, we see that the Necessity involved in the Cause and Effect relation *cannot be* that of the Cause necessitating the Effect, since this does not always *necessarily* occur.

Rather, what *will always be necessary* in the Cause and Effect relationship is the pre-existence (or actual material Antecedence) of any Cause or Causes of an Effect that has *actually occurred*. Thus the Necessity involved in Causation is that of the *necessity* of the *pre-existence* of the Cause of an existing Effect; rather than the other way round. In fact, the *necessary antecedence* of the Cause follows directly from the first property of Causation that is assigned by Hume, the notion of Contiguity. By its '-tig-' root, the relation of Contiguity insists upon a *physical* connection between *material* objects and/or events. And since Hume has restricted his analysis of Causation to forms of *Material* Causation, the relation of Causality, as Hume views it, must be contiguous. Accordingly, the actual physical existence of an Effect requires the actual physical existence of the Cause; otherwise, the nature of this physical process could not be physical throughout the extent of the process—that is, it would not be contiguous. Accordingly, the notion that the physical existence of a Effect *necessitates* the physical existence of its Cause follows directly from the physical Contiguity of the relation. In addition, Contiguity leads also to the second notion involved in Hume's explanation of Causality, that of Antecedence.[14] What Antecedence requires is that a Cause must always precede, in time, the Effect that it brings about. But of course, if the presence of an Effect requires the existence of its Cause and, in addition, the Effect is something that is the result of, or derives or follows from, its Cause—that is, if the Cause serves to contiguously bring about the Effect—then the Cause must have been physically present *prior to*—Antecedent to—the Effect.

In the list of rules given by Hume, Contiguity is the first property of Causation; and as we have seen Antecedence, the second property, and Constant Conjunction, the third, follow from Contiguity. As for the fourth rule, it expresses what may be called the Uniformity of Causation; and it is as follows:

> *Uniformity:* Every Cause always produces the same Effect; and the same Effect never occurs except as the Effect of the same Cause.

Simply put, Uniformity means that every time, and in every instance—that is, for *all* cases, *universally*—a given Cause always produces the same Effect, and a given Effect is always produced by the same Cause. And because of this universal nature of Causation, the analysis of specific Causes and their Effects can be carried on by different people, at different times, in different laboratories. In addition, since *all* cases of a given Effect are necessarily preceded by its Cause, every particular instance of this Effect can be explained wholly by means of this same Cause. And finally, this explanatory power, which we call Explicability, gives Causation a significant role in our scientific explanation and understanding of the World. We may thus conclude that the defining essence of the Causal relation can be laid out as follows:

Functional Relations among the Characteristics of Causality:

Contiguity
Universality { Antecedence } Explicability
Necessity

And here, finally, we have a suitable explanation of the nature of Causality, for in any causal relation there will inevitably be a *contiguous* physical connection (Contiguity) between the Cause and the Effect, the former of which must *necessarily* have been present (Necessity) *beforehand* (Antecedence) in order for the Effect to have occurred; and this necessary and antecedent physical connection can be used in *every* case (Universality) to *explicate* (Explicability) or explain the causal situation.

Methods of Causal Analysis

The remaining rules for judging Causality on Hume's list are not, as the preceding rules were, essential characteristics of Causation. Rather, they (or, at least, the first three rules) constitute an early version of what have come to be known as Mill's Methods of Causal Analysis. As Hume's list clearly shows, however, the rules attributed to John Stuart Mill were first given, albeit in cursory form, by Hume. The fourth rule, that of Sufficient Causes, is itself a sort of definition of 'Sufficient Cause', even if it be definition by negation. These four rules are given below, and they are listed by titles (in italics) supplied by the present author to suggest their relation to Mill's Methods.

Hume's Four Rules of Causation:

Agreement: Different objects that produce similar Effects must have a *common property* as the Cause of the Effect.

Differences: Similar objects that produce different Effects must have *different properties* as the Causes of the different Effects.

Concomitant Variation and Residues: Effects that change (or are absent) *when a part of the Cause changes* (or is absent) are Effects of *that* part of the Cause.

Sufficient vs Necessary Causes: Causes that *do not produce Effects unless supplemented* by other Causes are not Sufficient Causes.

Given the connection of these Humean "rules" and John Stuart Mill's "methods", as well as the thoroughgoing development that these methods received in the hands of the great English philosopher, we shall defer to the latter and utilize his ideas about the nature of Causality. As I have mentioned, these "rules" are now know as Mill's Methods for the investigation of causal relations, and in their standard form these five methods are as follows:

1) The Method of Agreement
2) The Method of Difference
3) The Method of Agreement and Difference
4) The Method of Residues
5) The Method of Concomitant Variation.

As we shall see, the full statement of each these Methods is clearly reminiscent of Hume's language, as given above. As we have them here, however, it is clear that the *name* of each of these methods is reminiscent of Hume's Rules, while Hume's language itself is reminiscent of Bacon's Tables. In particular, Bacon's first table contains items that are in "agreement", in the sense of sharing a *common property*; the language of

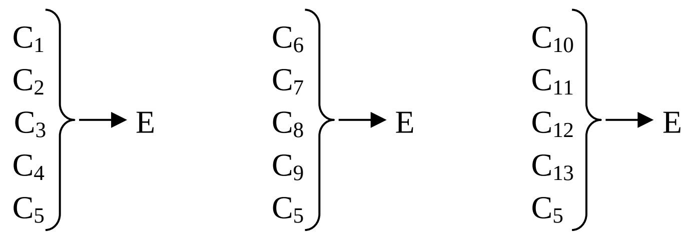
Hume's first Rule explicitly speaks of different objects that produce the same Effect as "having a common quality", and thus being "in agreement"; and Mill's first Method is the Method of Agreement Similarly, the name of Mill's second method seems to be a modification of Bacon's second table; and Mill's third, the Method of Agreement and Difference, merely combines the first and second methods, much as Bacon's third table brings together various methods of comparison. Mill's fourth method too, that of Concomitant Variation, employs a comparative technique not unlike that of Bacon's third table, although Mill's Method extends well beyond Bacon's requirements, and in fact derives from Hume's third Rule, above. In Mill's version of this, for instance, the tactic is to keep most of the causes the same for several different experimental situations while allowing one possible Cause—say, the speed of the wind during a wildfire—to vary from one instance to the next. By this means, we presume, we will discover that, for instance, the faster the wind blows, the faster a wildfire spreads, and the slower the wind blows, the slower the fire spreads. Thus, the *variation* in the speed at which the fire spreads (and in general, any variation in an Effect) is seen to be *concomitant* with—that is, to be directly related to—the speed at which the winds blow (and in general, a variation in the Cause). And finally, Mill's fifth method, the Method of Residues, says that since it is just the *speed* of the wind that effects the *speed* of the fire, only the speed of the wind and not something else—like the temperature or the *direction* of the wind—is the Cause of the speed of the fire.

Setting aside all material aspects—for instance, the specific wildfire situations of the above examples—we may investigate Mill's Methods in terms of their structure alone by means of a purely formal approach, an approach that allows a more general understanding of the methods. And what this approach shows us (among other things) is that in the main the greater the number of *different but analogous* situations in which the *contiguity* between a possible Cause and an Effect is confirmed, the more alternative possible-Causes are ruled out. This is tantamount to saying that with Mill's Methods we can increase the probability that a circumstance that has been posited as *the likely Cause* in a causal situation is in fact *the actual Cause*. In addition, the greater the number of ways in which we can vary or modify other aspects that accompany the possible Cause, or even modify the possible Cause itself, and thereby produce corresponding variations (the traditional phrase is "concomitant variations") in the Effect, the greater the probability that the possible Cause is the actual Cause.

These several methods may be better understood by means of the somewhat more illuminating illustrations given below. Beginning with Method I, we find various circumstances—each of which is labeled C for 'Circumstance' (and, potentially, for 'Cause') and given a unique, identifying subscript—that might contribute to the causation of some event, E. Each of the subsequent methods alters the circumstances in various ways, in hopes thereby of discovering which circumstance is actually the Cause of event E. Event E is then said to be the Effect of the determined Cause. In the explanation given below, the Method is first described and explained in terms of the manner in which the Method operates. And below the explanation a diagram is given to illustrate what the description is attempting to explain.

Mill's Methods of Causal Investigation:

> *Method I) The Method of Agreement:* If two or more instances of a given event E occur, in each of which instances there are several circumstances C_n but one only that is the same in all instances, then the instances may be said to *agree* in this respect, and we may infer that the one circumstance that appears in all instances is actually the Cause of the event E, which we now call the Effect.

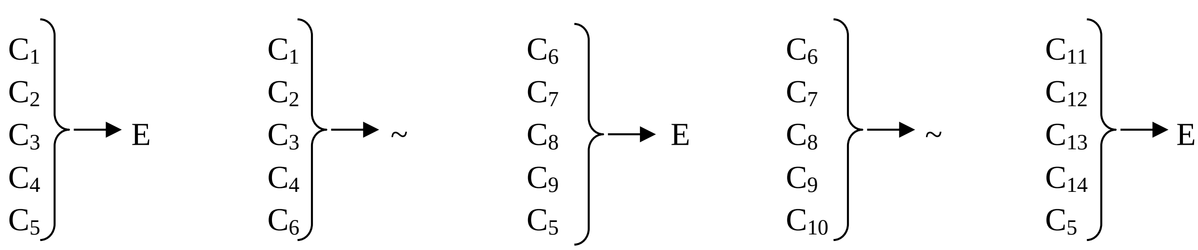


In the first of Mill's Methods—known as the Method of Agreement, illustrated above—the investigator devises several instances of an experiment in which each instance differs from the others in all but one purportedly causal circumstance. If, in each of these instances, the desired Effect is nevertheless produced, then we may infer that the one circumstance in which each of the instances *actually agree* is the actual Cause of the Effect produced. In the example given above, it is assumed that one of the causal circumstances—in this case, C_5, which appears in all the instances—is in fact the actual Cause of event E, the Effect (although at the outset of the experiment the investigator have no inkling of this). In the left-most instance of the illustration, the first instance of our example experiment, the relevant circumstances (and potential Causes) are represented by the labels C_1 through C_5, while the Effect is represented by the E at the end of the "arrow of causality". After just this one experiment, however, the investigator has not yet gained enough information to determine which of the five circumstances is the actual Cause, other instances of the experiment being required. Applying Mill's Method to produce the second instance, then (in the middle of the example), the experiment is modified, with the four circumstances labeled C_1 through C_4 in the first instance being replaced with circumstances C_6, C_7, C_8, and C_9, respectively. Circumstance C_5 is kept in place, however, and this turns out to be a good guess (or at least a happy accident for the investigator in this case), for with this move the investigator has coincidently retained the one circumstance (C_5) that also happens to be the actual

Cause of E. As a result, these two particular instances do in fact provide the investigator with enough information to infer that C_5 causes E; but, seeing as how this conclusion receives its support from only two instances of the experiment, this leaves the investigator with little assurance that his or her conclusion is sound. Accordingly, the investigator produces yet another instance of the experiment (as illustrated in the right-most instance, above), aimed at further isolating the inferred Cause, C_5. And in once again, when circumstance C5 is present, even though all other circumstances are different, yet the same Effect, E, is produced. Now, however, since there is but one circumstance in which in which all three instances of the experiment agree, the investigator is reassured in his or her inference that this one circumstance, C5, is in fact the Cause that actually produces the Effect, E. And continuing in this manner, a suitable number of instances are eventually produced (although not shown) to allow the investigator to say, with confidence, that the inference regarding C_5—the one circumstance in which these various instances *agree*—is correct, and that C_5 is in fact *the* Cause of E.

In the next method, Mill's second—the Method of Differences, illustrated below—we find a situation similar to that in the previous method, in which we compared several instances of a particular causal situation. In contrast to the previous method, however, in which we *modified* all casual circumstances save one, in the present situation we *retain* all causal circumstances but one. And in this case, whenever we remove any circumstance that, when present, produces the Effect E, E fails to occur, whereas when we re-introduce the relevant circumstance, the Effect again appear. Accordingly, we isolate the actual Cause of this particular Effect.

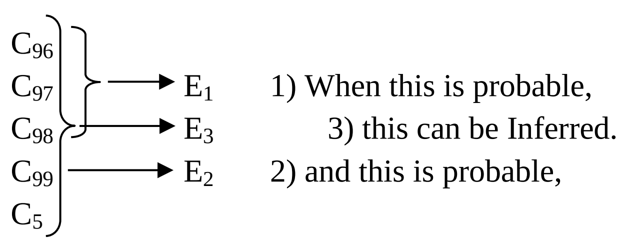
> *Method II) The Method of Difference:* If any two different instances exist for which all circumstances but one are the same, and if the event E results from the first instance but not the second, then we may infer that the circumstance present in the first instance but not in the second is the Cause of E, the Effect.



Thus, as we see in the first instance of the experiment, a collection of five circumstances causes the appearance of event E, which is obviously the Effect of one of these circumstances. To determine which, we retain the first four of these five circumstances, but replace the fifth with yet another circumstance, C_6. As a result of this, however, the event E is not produced, and the most natural response to this is to conjecture that C_5 was actually the Cause of E. Having, albeit, very little evidence in support of this conjecture, the investigator produces another instance of the experiment (given in the middle of the diagram), in which C_5 is reintroduced along with four other circumstances that had not been involved in either of the first two instances. Consequently, the Effect E is again produced, and our conjecture that C_5 is in fact the Cause of E is reinforced. In the fourth instance, then, all circumstances from the previous instance except C_5 are retained, while C_5 itself is replaced with yet another circumstance, C_{10}; and once again the Effect E does not appear. And in the final instance, C_5 is once again reintroduced, along with four new circumstance; and once again the Effect E is produced, thus confirming our conjecture that C_5 is the Cause of the Effect E.

Skipping over Mill's third method (which merely combines methods I and II), we find that in Method IV—the Method of Residues, illustrated below—the intention is to isolate known Causes of partial Effects of a complex Effect (which, below, combines E_1, E_2, and E_3) and remove as many of the circumstances (here C_{96} through C_{99}) that are known to be Causes of the partial Effects (E_1 and E_2). By this means, we are able to identify the single *residual* circumstance C_5 as the actual Cause of this *residual* Effect, E_3.

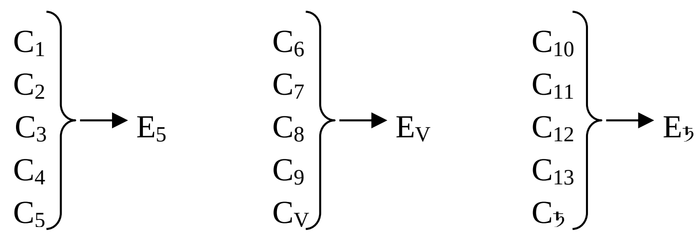
> *Method IV) The Method of Residues:* When a sub-part of a complex situation is held to be the Effect of well-defined (i.e., highly-probable) Causes—as here, where E_1 is known to be the Effect of the combined Causes C_{96}, C_{97}, and C_{98}, and E_2 the Effect of Cause C_{99}—then the remaining Effect (here, E_3) of this complex situation can, with a high degree of probability, be Inferred to be the Effect of the remaining Cause, C_5.



And finally, in Mill's last method, the Method of Concomitant Variation—illustrated below—we find a slightly different situation, for in this case we have more of less identified a circumstance as the likely Cause of the Effect. To reinforce our suspicion, then, the investigator performs several variations of the experiment in which the suspected Cause is modified slightly in hopes of producing a concomitant variation in the

Effect. And as we see in the three instances of the experiment given below, circumstance C_5 produces the Effect-variation E_5, while the variations C_V (where the subscripted $_V$ is the Roman Numeral for '5') and C_W (where the subscripted W represents a second variation) produce the concomitant variations E_V and E_W, respectively. Consequently, we may infer that C_5 is in fact the Cause of E_5.

> *Method V) The Method of Concomitant Variation:* When variations in one situation are correlated, to a high probability, with variations in different situations, a Causal relations may be Inferred with a high probability.



This completes our investigation of Mill's Methods of causal analysis, and with it our investigation of the traditional forms of Causality. As it turns out, however, these traditional forms of Causality have, like so many of the scientific ideas that we have received from the Classical (and even the early Modern) period of the Western tradition, have been supplanted by more rigorous versions. For Causality, as we shall now see, these more rigorous advances include modifications of the notion of Causality itself as well as new ideas of what exactly is involved in the production of an Effect from a Cause.

Probability and Feedback—New Notions of Causality

The first of the modern advances that have allowed us a deeper understanding of the physical world is a result of the advent of computers and Computer Science. The ideas and machines developed by computer scientists and technicians has increased the calculating power of the human mind, if only by freeing it up from the untold tedious calculations and mathematical analyses that are now carried out by computers. As a result, our understanding of relevant aspects of the World is increasing exponentially; and advances in one field are fueling advances in other fields. The overall result is an emerging comprehensive understanding of all relevant aspects of the World, from the smallest—in Quantum Theory—to the largest—in Cosmology itself. And what we learn in the one field can, and perhaps must, alter our understanding on the other.

In Quantum Physics, for example, the traditional notion of Causality as this was garnered from *macroscopic* approach (and which was discussed at length, above) was soon discovered to be inadequate to an understanding of the *microscopic* world. There, due to the non-intuitive nature of Quantum objects, it simply is not possible to accurately determine the causal relationship between a singe Quantum element as a Cause and its presumed Effect. Rather, the best we can expect is a sort of statistical averaging of the causal relationship of innumerable Quantum elements; and this requirement turns the notion of Causation into a probabilistic affair. As a result, Probability Theory becomes critical in the understanding of Causality; this, however, is an aspect of the Logic of Science that is beyond the current discussion.

In addition to the notion of Probability, Computer Science turned our focus to a second concept that affects our understanding of Causality, the notion of Feedback. In its modern form, the interest in this subject derives from the use of computers as cybernetic or *control* devices. In this application of computers, it is sometimes the case that the Effects of the Control Device can be "fed back" into the machine, and made to influence how the Control Device functions. In other words, the Effect becomes part of the Cause. In this process, the Feedback can be made to influence the device in a way that increases the "power" of the Cause—a type of influence known as Positive Feedback—or decreases the Cause—known as Negative Feedback. The overall effect of all of these (and other) ideas that change the way we look at Causation is that our traditional understanding of the natural process, which emerged in reaction to the macroscopic World, cannot be directly applied to the microcosmic realm. Once again, however, we have come upon an aspect of the Logic of Science that transcends the scope of the present text.

At this time, then, we shall leave of our analysis of the Logics of Causality and proceed to an analysis of the third and last of the Logics of Discovery, the Logic of Material Analogy: the Logic of Induction.

Induction — The Logic of Material Analogy:

As we have learned, Science is an investigation of the Material nature of the World, one that is greatly aided by the investigation of the Formal aspects of the World that have been advanced by Philosophy. Accordingly, the Logics of Science are divided into Material Logics—the Logics of Discovery—and Formal Logic—the Logic of Corroboration; our Logical investigations thus far have focused upon the former. To this point, we have considered only the Logics of Causality; now the time has come to consider the Logics of Analogy. As with the Logics of Causality, there are two Logics of Analogy: the Logics of Induction and Deduction. However, as it turns out, only one of these Logics is a Material Logic; for unlike Causality, Analogy has Formal, as well as Material, aspects.

In particular, Inductive Logic, the Logic of Material Analogy, concerns itself with what we have called Natural Kinds: a Kind is a plurality of material objects that, by their very nature, have certain properties in common and thus form a natural class of *materially analogous* members. An example of a Natural Kind would be any species of living things, in which, as we now know, the members or conspecifics have common properties due to their being genetically related to each other. In contrast, Deductive Logic, which is the Logic of Formal Analogy, strips its Symbols of all material content, leaving only the Formal aspects intact. From this starting point, Deduction proceeds to stipulate (by means of Axioms) the properties of an artificial class of analogous objects, and to extract the specific members (as Theorems) of this Formal class by means of the Deductive process. In the current chapter, we have been and will continue to concentrate upon the Material type of Analogy and its respective Inductive Logic; while reserving the study of Deductive Logic for the next chapter.

To begin, then, we define *Induction* as "Hypothesizing a Generalization from a set of Analogous Observations or Properties." In other words, to Induce a Generalization for a Natural Kind from Specific observations of members of the Kind is to *surmise* that the Generalization must be the case because the observed specifics are members of the Natural Kind and, since these are Analogous, all members of that Kind must be analogous. Accordingly, when we Induce a Generalization we are attempting to explain a *Universal* object (a Natural Kind) *after the fact*, and we do so by determining a common property of observed objects and "inducing" a general, universal property for *all* members of the Natural Kind. Consequently, we say that Induction is *surmising a Universal Class,* A Posteriori or "after" we have observed a sampling of Members of material objects.

The following two examples are simple illustrations of the structure of Inductive arguments concerning material objects:

Example #1:	*Grounds:*	*Logical Form:*
I saw a cow and it had 2 horns.	Observation	1. $\{\exists ! o \mid \mathcal{C}(o) \wedge \mathcal{T}(o)$
If all cows are the same, then all cows will have two horns.	Analogical Hypothesis	2. $\forall a,b : [\mathcal{C}(a) \approx \mathcal{C}(b)] \Rightarrow \forall o : \mathcal{C}(o) \Rightarrow \mathcal{T}(o)$
All cows have two horns.	Inductive Generalization	3. $\forall o : \mathcal{C}(o) \Rightarrow \mathcal{T}(o)$

Example #2:	*Grounds:*	*Logical Form:*
Electron1 has mass M_1.	Observation	1. $\{\exists ! o \mid \mathcal{E}(o) \wedge \mathcal{M}_1(o)$

If all electrons are the same, then electrons have the same mass.	Analogical Hypothesis	2. $\forall a,b : [\mathcal{E}(a) \approx \mathcal{E}(b)] \Rightarrow \forall o : \mathcal{E}(o) \Rightarrow \mathcal{M}_1(o)$
All electrons have the same mass.	Inductive Generalization	3. $\forall o : \mathcal{E}(o) \Rightarrow \mathcal{M}_1(o)$

As we see, Inductive reasoning begins, as does Abductive reasoning, with an Observation of the World. This is necessary, again, because Inductive Logic is reasoning about the relation of Analogy among various *material* objects. Next comes the Analogical Hypothesis: a is Analogous to b, and so if a has Property M_1, then b would have Property M_1 as a matter of course. For this reason alone Inductive Logic is said to be a type of Hypothesization; and thus, as we have seen, all forms of Material Logic are hypothetical. And finally, the Conclusion of the argument is called the Inductive Generalization in order to underscore the fact that our Logic here is Inductive. When we put all of this together into a statement that summarizes this process, we have what we may call the *Inductive Rule*:

If all observed objects are Q, then all objects of this kind are Q.

Examples of Inductive Reasoning

Examples of Inductive Logic abound in Science, if only because many of the so-called Laws of Science are Inductive Generalizations. Consider, for example, Newton's third Law of Motion, which states that "For every action there is an equal but opposite reaction." Clearly, Newton could not have observed every action, if only because innumerable actions occurred before Newton was born, and actions have continued to occur since Newton's death. Accordingly, the phrase "For every action", which could also be rendered "For *all* actions", must denote an Inductive Generalization. That is, "All observed actions include an equal but opposite reaction; and if all actions are analogous in this respect, then all actions will include equal but opposite reactions; thus, "For every action etc."

As a second example, consider the observation that sea shells are found at distances far removed from the sea, and often on the slopes of mountains and hills. Now this physical situation is somewhat of a dilemma, because sea shells are quite naturally associated with sea creatures, many of whom are known to make and use sea shells. And of course if this peculiar situation on the mountain side had been observed only once, we might be persuaded that it was accidental and that the seashell had perhaps been carried to the mountain side by some person or some animal. As it is, however, repeated observations have been recorded of sea shells being found on mountain-sides, and in general in areas where there is at present no sea; and these observations thus stand in need of an explanation. Fortunately, an explanation is ready at hand, for we know that in the sea, where sea shells are typically found, sea creatures create the shells, and when these creatures discard their shells they settle on the bottom of the sea. From a reasonable number of specific observations of such occurrences, then, we could make the general assumption that *all* observable sea shells were made by creatures in one sea or another. And given this, we could safely conclude that even the sea shells found on mountain sides were made by sea creatures. All that is required to make the situation on the mountain-side seem as natural as that of the sea shells is for this part of the land, which is now a mountain, to have been at some earlier time a part of the floor of some sea.

Material Analogy — Aspects of Isomorphism

Figure 3-4 illustrates this Inductive argument in its specific form, which is seen in the diagram below, while a more general illustration of Induction is given in Figure 3-5,

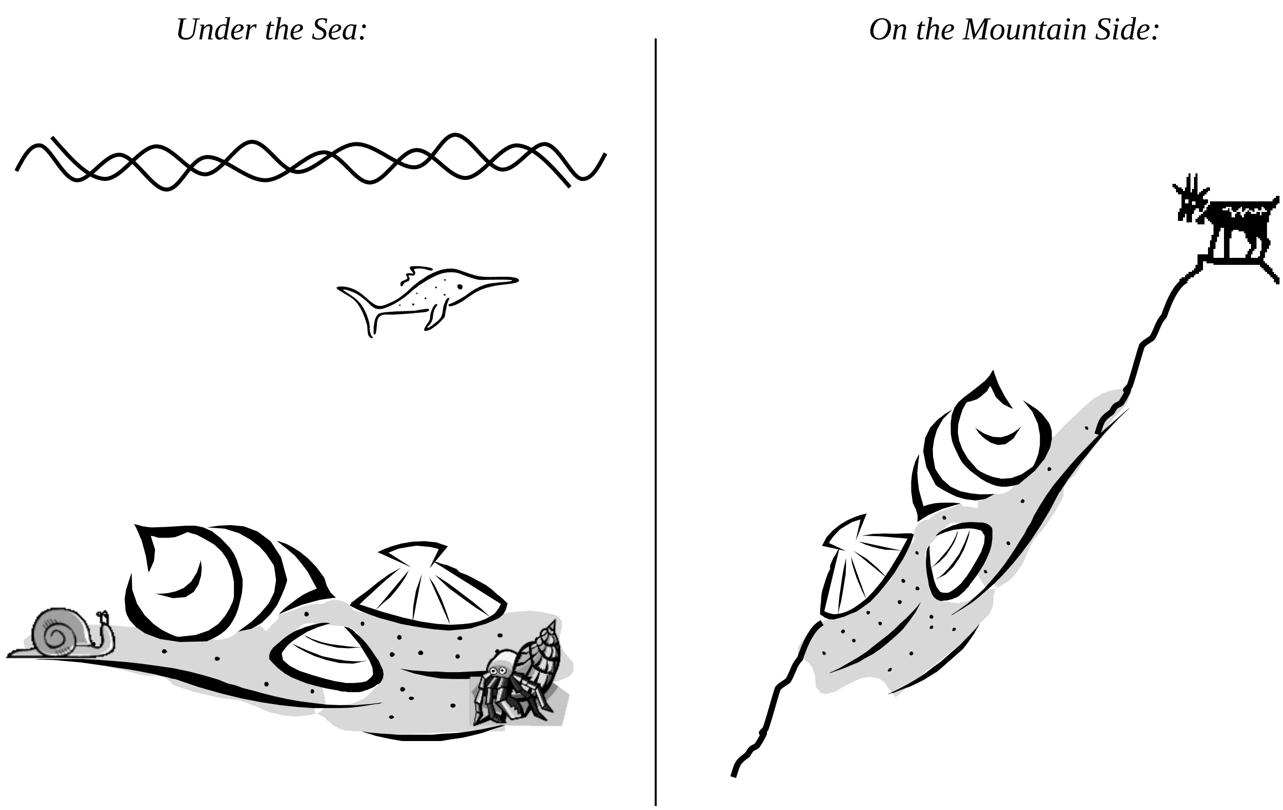


Figure 3-4. An Illustration of Scientific Induction

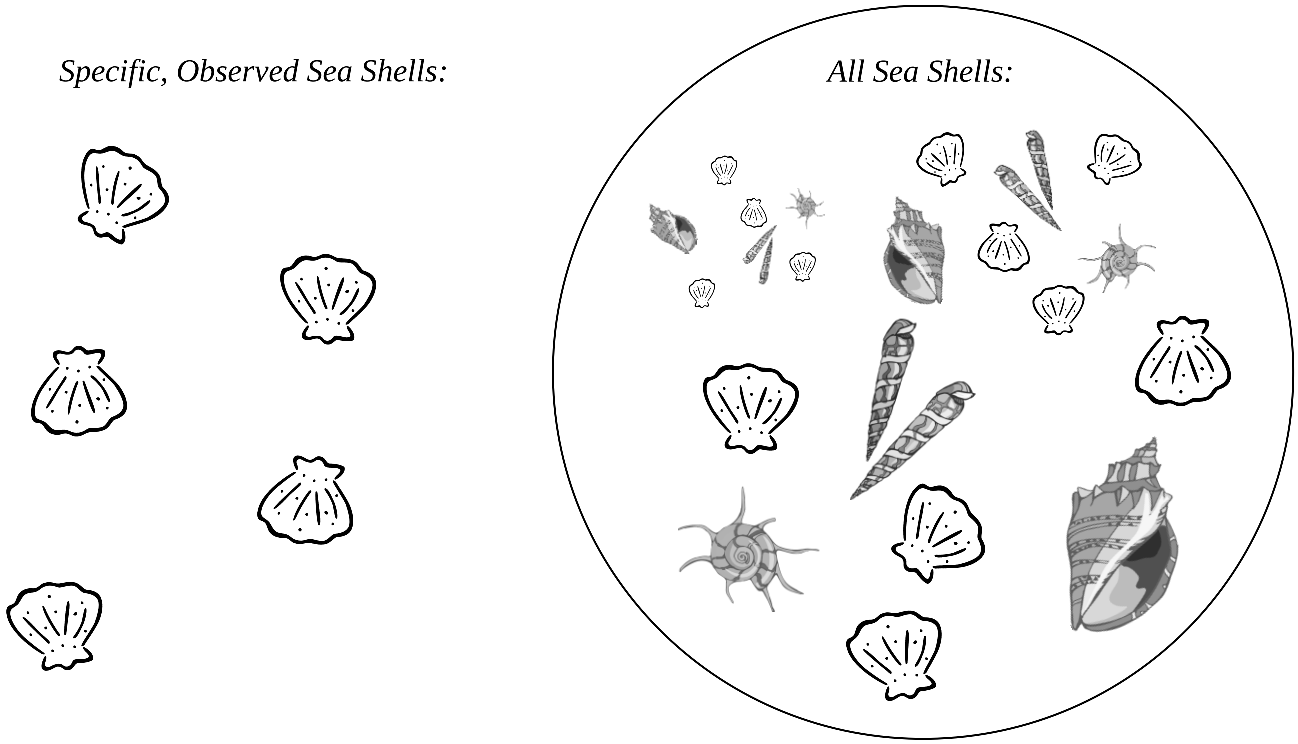


Figure 3-5. An Illustration of Scientific Induction

above. Taking the specific form first, we note that specific observations of the sea itself teaches us that sea shells are made by certain sea creatures who deposit their shells on the sea bottom. Accordingly, we can take this lesson and apply it to *all* sea shells, even those we find on a mountain, and propose that the mountain must once have been under water. And more generally (as in Figure 3-5, below), given say five specific observations of sea shells being made by sea creatures, we can make an assumption that this is in fact the case even for sea shells that we did not see being made, and we can even generalize this to be the case for *all* sea shells. Thus, again, we can surmise—by means of Induction—that mountains with sea shells must once have been under the sea. And of course if we are correct, then we have amplified our knowledge about the real world, and thereby demonstrated the *ampliative* nature of Induction.

At this point, unfortunately, we have come face to face with what is called the Problem of Induction (as the "if" in the previous sentence should suggest). For although in this example we have made but a handful of observations (as we do with every inductive argument), we have yet *gone further* than that, and have said something about *all* sea shells, and thus about all sea shells that will ever be observed. But since all sea shells could never be observed, we have actually *smuggled in*, as it were (and that without warrant), the universal notion of *all* sea shells. As a result, even if we could assume that the observations that we do actually make are never wrong (which would still guarantee *only* our knowledge of how *actually observed* sea shells come into being), we could very possibly be wrong when it comes to our generalization about *all* sea shells, the bulk of which have never been and could never be observed.

Returning to the example of an Inductive argument that was illustrated in Figure 3-4, we see that it actually shows us more than just the general nature of Induction. In fact, it illustrates the roles of both Analogy and Causality in the scientific method. For, as it stands, the seashell analogy as diagrammed in Figure 3-4 compares two different realms or regions—the sea and the mountain side—with the express purpose of using any similarities between these two regions to lead us to more information—to *ampliate* or increase our knowledge—of the one poorly understood phenomenon (mountain shells) in terms of the other, more well-understood phenomenon (sea shells). In this particular case, in which we want to explain the presence of sea shells on the mountain side, we use the presence of sea shells in the sea (by way of Analogy), along with our knowledge of how these shells came to be there (which involves Causality), to explain the presence of shells on the mountain. The *comparison* involved here—between the sea shells and the mountain shells—is thus used to elicit a *cause* for the presence of the mountain shells. To put it in mathematical form, we could write out the fact that “sea creatures create sea shells” as:

sea creatures / sea shells

so that the notion that sea creatures are somehow related to sea shells now has the form n/m, the form of a ratio. And we can compare this ratio, metaphorically speaking, to another ratio: that of the cause of mountain shells to the shells themselves. Unfortunately, however, at this point we do not yet know the cause of the mountain shells, and so this second ratio, written mathematically, must take the form:

x / mountain shells

where x represents the unknown cause of the shells found on the mountain side. The mathematical proportion, or Analogy, then, would have the form:

sea creatures / sea shells = x / mountain shells,

which in Classical proportional notation turns out to be:

sea creatures : sea shells : : x : mountain shells.

Of course, this is read as “Sea creatures are to sea shells as x is to mountain shells.”; and what we want to know is, “What is the value of x?” or, in other words, “What is the cause of shells in the mountains?" Fortunately, Induction—which here says that, since all observed sea shells are caused by sea creatures, and since (by the inductive generalization) all shells in general should have the same cause, we do know the cause of mountain shells—allows us to fill in the value of x. Consequently, our Analogy ultimately becomes:

sea creatures : sea shells : : sea creatures : mountain shells,

in which we now have an intuitive explanation of why there are sea shells on the sides of mountain: the land that is now a mountain used to lie at the bottom of a sea that contained sea creatures who made the shells.

Although this example is perhaps too simplistic to show it, Analogy can be quite useful in science. At the same time, our focus on Analogy might have caused us to miss the role of Causality that is also involved here as well. For, although Causality does not always play a role in analogical explanations (as we will see in the next example), it often does, and we want to be sure not to miss what is happening in this specific situation. In particular, for this Analogy, the unknown term x represents the cause of the shells on the mountain side, so that when we determined the "value" of x by means of the Analogy, what we really were doing was using this *analogical* relationship to inform us as to the *cause* of sea shells found on the mountain side. Thus in this example both Analogy and Causality work together to supply us with a scientific explanation of a part of our world. As scientific explanations go, of course, this particular example is a bit trivial; nevertheless, this example *does* constitute a scientific explanation, and in fact it is one of the earliest scientific explanations ever recorded. For this particular explanation comes from the Greek philosopher Xenophánes, who some twenty-five hundred years ago offered this Analogy to explain the presence of sea shells on the mountains of Southern Italy, where he lived

A second example of an Analogy, and this time one that turned out to be extremely influential both in Science and the Philosophy of Science, is often cited in texts that discuss the scientific method. As the story goes, the chemist August Kekulé had been struggling to discern the chemical structure of benzene, when an analogical image came to him literally in a dream. One famous philosopher of science, Carl G. Hempel, tells the story this way:

> The chemist Kekulé, for example, tells us that he had long been trying unsuccessfully to devise a structural formula for the benzene molecule when, one evening in 1865, he found a solution to his problem while he was dozing in front of his fireplace. Gazing into the flames, he seemed to see atoms dancing in snakelike arrays. Suddenly, one of the snakes formed a ring by seizing hold of its own tail and then whirled mockingly

> before him. Kekulé awoke in a flash: he had hit upon the now famous and familiar idea of representing the molecular structure of benzene by a hexagonal ring. He spent the rest of the night working out the consequences of this hypothesis.[15]

As we see from the story, then, Kekulé's analogical figure not only helped him intuitively understand the scientific problem that had perplexed him—the structure of the benzene ring; it also inspired him to continue his more rigorous, deductive work.

A final, and somewhat more significant, example of scientific Analogy is shown in Figure 3-6 below, which illustrates the attempt by scientists of the late nineteenth and early twentieth centuries to understand the structure of atoms. On the right-hand side of the upper part of the figure we see an early version of what the structure of the atom was believed to be, while on the left-hand side we have the model that inspired the insight. This model represents our Solar System, with the Sun in the middle and the Earth, in four different configurations, circling the Sun. Prior to the development of this model, scientists had been trying to imagine what an atom might look like, if one were able to see it. On the basis of this model of the Solar System, someone suggested that the atom could be visualized as having a center—what we now call the nucleus—that contained something that acted like the Sun, having certain planet-like bodies—what we now know as electrons—that circled this central body in the same way that the planets circle the Sun. And once they had this model, not only their attempts to make sense of the atom but the work with atoms in the laboratory, as well, benefited. Eventually, however, some other scientist pointed out that, due to the laws of planetary physics, the planets would gradually loose the energy that kept them circling the Sun, and sooner or later they would spiral into the Sun-like central body. On the basis of the model, again, this was assumed to be true also of the electrons circling the nucleus of the atom; but when experiments were devised to investigate these supposed atomic properties, the scientists received quite a surprise. For, instead of spiraling into the nucleus, the less energetic bodies merely assumed an orbit somewhat closer to it and, once there, the electrons seemed to be as stable as they were in their more distant orbits. In addition, whereas a spiraling planet—and presumably a spiraling electron—would loose energy continuously as it followed a continuous spiral into the Sun, the energy released by the electrons came out of the atom in discrete packets, just the opposite of what was expected.

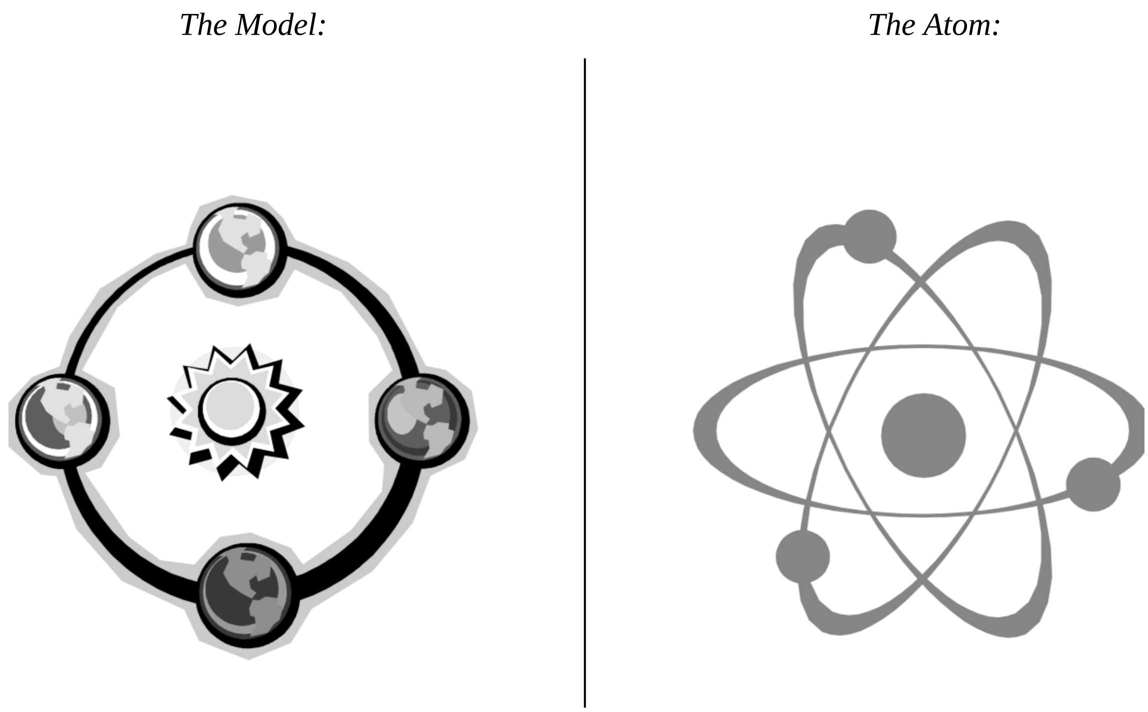


Figure 3-6. Analogies for Understanding Atomic Structure

Needless to say, the scientist were perplexed, because the atom was not acting like a Solar System at all. And in fact the electrons, which had been assumed to be small particles in the manner in which planets are big particles, were not acting like particles. Rather they were acting almost as if they were wave-forms of pure vibrational energy, pulsating around the nucleus of the atom much like the body of bell pulsates when it is struck. Accordingly, the atomic model given in diagram below, in Figure 3-7 , is that of a bell, which we see on the left-hand side of the diagram. On the right-hand side, across from the bell, we have a rendering of an atom based on this model, in which the nucleus appears as a dark, unknown dot, but the electron now has the much more realistic form of a circular wave. Here, the wavelength is 1/4 of the circle, and accordingly we can see four sets of peaks and troughs lined around the nucleus (in the figure, the wave is shown in two different positions, giving the appearance of eight waves). This wave is sitting at a particular distance from the nucleus, according to the amount of energy possessed by the wave. Were the wave to loose a discreet amount of energy, however, it would not spiral into the nucleus (a situation that does not even make sense for a circular wave); rather, it would merely disappear from its present orbital (not its "orbit", because the electron is now not a particle—hence we use the term 'orbital') and reappear in an orbital somewhat closer to the nucleus. This new model of the atom, thus, is much more realistic—allowing for more accurate predictions about it—than the model of the atom as a planetary system.

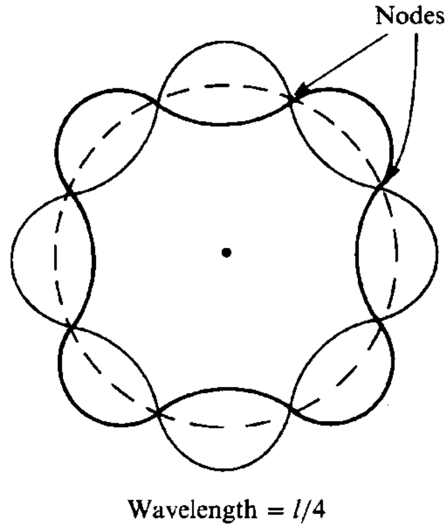


Figure 3-7. Analogies for Understanding Atomic Structure

In this example we can see quite nicely the utility of analogical arguments; they can give us an intuitive grasp of the natural systems we are trying to understand in Science. At the same time, however, we can also see the shortcomings of analogies. With respect to the planetary model, for instance, the *usefulness* of this analogy is illustrated by the progress made in atomic physics after the physicists used the model to visualize the atom in a particular manner. At the same time, the *limitations* of this particular analogy become evident when the physicists attempted to make the atom behave *in all respects* as if it were a little planetary system. And similarly, s we know all too well, ultimately *all* analogies eventually break down (unless of course the systems compared are actually perfectly Isomorphic, which is rarely the case), and thus arises the pertinent question: "How far can we take our Analogies?" In the second model of the atom proposed here, that of the bell, the analogy—between the vibrating shell of the bell and the vibrational electron—rings truer (no pun intended); nor would one in his or her right mind be tempted to extend the analogy beyond this point, because bells and electrons are just too dissimilar. Nevertheless, even this analogy is somewhat misleading, because the wave-form of the electron may not actually be a material wave-from, as is that of the bell itself. Consequently, we must proceed with caution when using even this perspicuous analogy.

How then are we to assess the value of arguments based on Analogy? Fortunately, there are several serviceable criteria, and we can perhaps do no better than simply to list them as follows:[16]

1) The more situations that we understand and to which we can compare the situation we are trying to understand—in short, the more analogs we can find—the stronger the argument will be;

2) the greater the variety of situations we that compare positively to the situation we are trying to understand, the stronger the argument;

3) the more similarities there are in the situation that we understand, compared to the situation we are trying to understand, the stronger the analogical argument;

4) a single factor (in the situation that we already understand) that is highly relevant to the situation we are trying to understand will strengthen the argument, and this more than several factors that are only slightly relevant;

5) any factor in the situation we understand that is dissimilar to factors in the situation we are trying to understand will weaken the argument; and

6) the less comprehensive the claim of the situation we are trying to understand, the stronger the argument; and, vice versa, the more comprehensive the claim, the weaker the argument.

Following these criteria along the lines suggested by the examples given above, we are able to develop serviceable analogies for use in Science. And considering that here we are not advocating the use of Analogy to inductively establish the truth of our hypotheses—that is, we are not trying to *prove* anything—but rather merely to provide us with an intuitive understanding of the objects and systems for the express purpose of generating testable hypotheses, the Problem of Induction (which admittedly has not been removed from our method) is nonetheless rendered innocuous. In fact, we are willing to grant the Probabilistic (and therefore problematic) nature of Induction, because in those inductive cases in which we actually turn out to be right about Nature (although we can never be certain of it) we do in fact increase our understanding.

The several different forms of analogy that we have seen so far may be called “natural analogies”, not only because we are trying to understand natural situations, but also because we are using natural “models” to help us understand. Comparing the structure of an atom to that of a solar system, for instance, is a case in point, for both the atom and the solar system are natural systems. But using natural situations in our analogies is not the only way we can go, for we can and do compare natural situations to artificial situations—that is, we compare Nature to our inventions.

A classic example of such analogies involves our understanding of how the heart circulates the blood in our bodies. Before the modern scientific revolution, and in fact for some fourteen-hundred years, it was believed that the blood was circulated through the body in a manner similar to the ebb and flow—or back and forth motion—of the waves on a seashore. This oscillatory motion was believed to be caused by the dilation and contraction of the blood vessels, which cause the blood to more forward, as it were, when the vessels contracted, and backward when they dilated. And this, in fact, was the extent of our understanding from the time of the Greek physician Galen in the second century OCE until the first half of the seventeenth century, when William Harvey discovered the role of the heart in circulation, and thereby the correct explanation of the circulation of the blood. At about the same time the vacuum pump was invented, and this pump (which moves air through pipes in a manner similar to the way the blood is moved through the vessels), and the many other types of pumps invented since, have helped clarify Harvey's theory. Since that time, then, the standard analogy used to explain how the heart works has been by comparison to a pump, and the old analogy of the blood moving like the waves of the sea soon fell by the wayside.

Strictly speaking, of course, the heart is not merely *like* a pump, because in fact the heart actually *is* a pump, which effectively eliminates any need for a mere analogy. All the same, although the heart bears both a structural and functional resemblance to pumps in general, the heart—being organic—is ultimately different from any mechanical pump, and the recourse to Analogy in this case is certainly warranted. Nevertheless, even analogies based upon the actual identity of the two systems being compared can be strained. A telling example here would be the comparison between the Human brain and computers. Granted, there is much in the brain that is more or less identical to a computer: to begin with, the neurons themselves are not unlike electrical switches; and the connections between neurons functions in a manner very similar to they way the computer's circuitry functions. But this is about as far as the identity between brains and computers go, and in fact the brain is about as much like a computer as it is like the liver. As a result, many of the wonderful computational abilities of the Human brain far outstrip those of a computer; and ultimately the Analogy between brains and computers, like all good analogies, breaks down. Nevertheless, when used appropriately, even this false analogy is serviceable enough to our understanding of how the brain works.

Analogy, Isomorphism, and Mathematical Models

As the preceding discussion indicates, we are free to choose either natural or artificial models to help us understand the universe; and apparently artificial models can be just as serviceable to our understanding as are natural models. There is, however, yet another type of model that we have yet to consider—the models of modern mathematics—and this type of model has been of infinitely more help in Science than have all of the models thus far discussed. The reasons for this are not difficult to discover, for the lack of natural (or even artificial) analogies for many situations that we wish to understand in science comes as no surprise. In addition, however, when we do in fact construct a mathematical model of a natural situation, we have more-or-less complete control in our construction design, and this allows us the liberty to design a model that comes much closer to the situation we are trying to understand than do natural or artificial models. And ultimately, given today's computer systems, we can even implement our mathematical models on a computer system and in this way translate the mathematics into a form of Virtual Reality capable of being displayed on a computer screen. In fact, this kind of modeling is commonplace in the twenty-first century, occurring on a daily basis across the globe whenever someone needs to be trained for one thing or another. And in any training scenario, from flying an airplane to fighting a fire, a computer's Virtual Reality simulations of real-life situations can help train people without actually endangering their lives. And whether we recognize it at first glance or not, these computer simulations are types of Analogy, for they are mathematical analogies, as it were, based upon more-or-less precise, but wholly mathematical, models.

In order to appreciate this type of analogy, let us develop a very simple mathematical model of the World. In this example, however, the "World" (or at least the part of the World that we are modeling) is a plane surface—for instance, a clean sheet of printing paper. The model for this plane surface, then, will be a two-dimensional geometric grid (as illustrated in Figure 3-8, below). In this model we see two straight lines at right angles, with each of the lines regularly graduated with a series of positive and negative numbers). For the sake of our experiment, we have superimposed the model upon the sheet of paper, and we will assume that the sheet of paper is held upright and that a light is being shined on it from the side. If we then toss a small object, like a marble, between the light and the paper, a shadow of the object will be cast onto the sheet. This shadow, in its entirety, is represented in Figure 3-8 by a curved line that has been traced out, as it were, by the shadow of the moving marble. The part of the physical world to be modeled, then, is the shadow-line cutting across the surface of the paper. The model—which is of course to say "the analogy"—can be represented in two different ways. The first representation is just the two-dimensional geometric grid, along with the geometric representation of the line. In this representation, for instance, the shape of the path of the marble is modeled by the shape of the line on the grid. But there is another, non-geometric representation available as well, for according to what is called Analytic Geometry every geometrical object—which includes our curved line—has an algebraic counterpart—a formula, that is (which in this case has the general form $y = x^2$)—that represents not only the geometrical curve itself but of course the actual path of the marble as well.

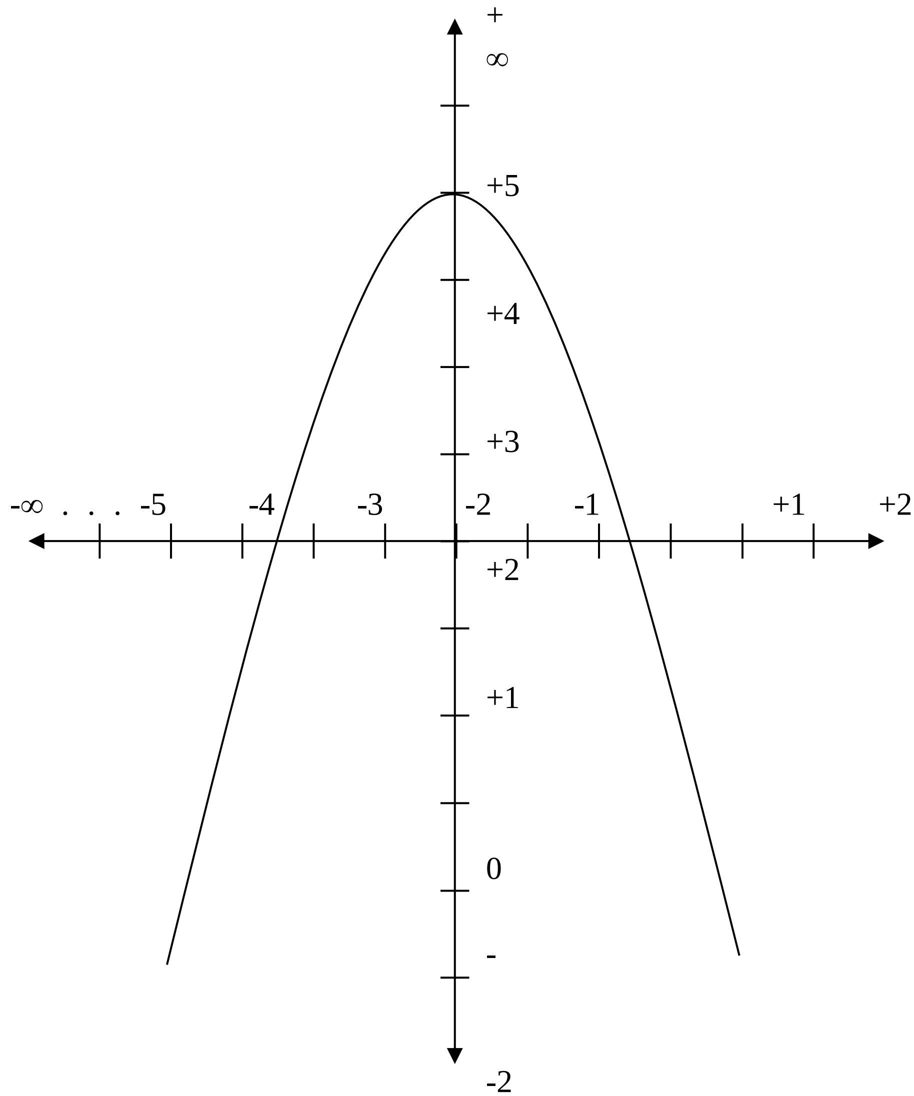
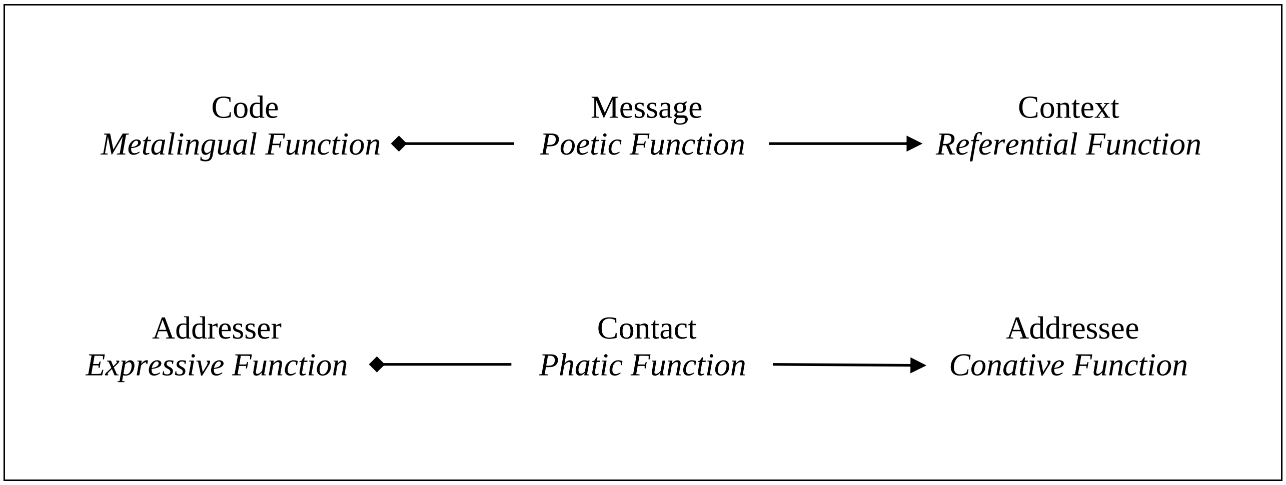
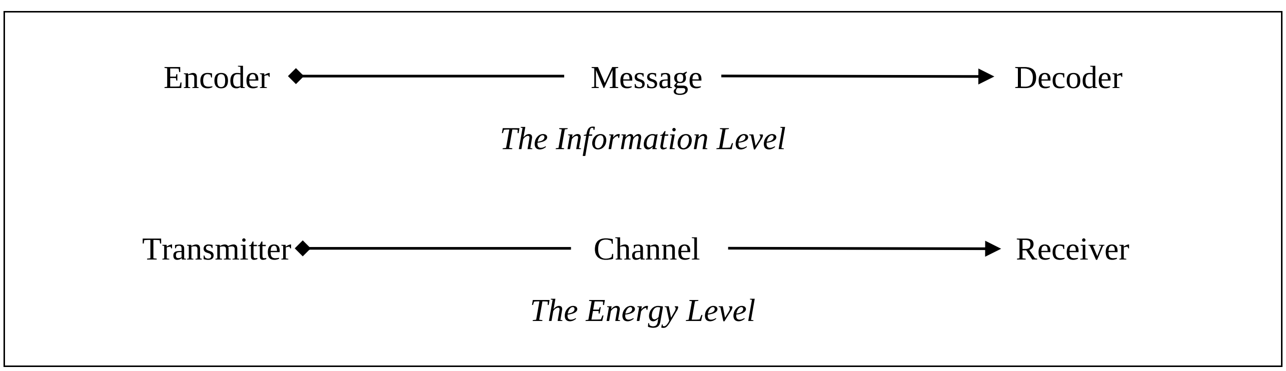


Figure 3-8. A Mathematical Model of a Plane Surface and the Shadow of a Moving Ball

This mathematical model, then—which is of course to say the artificial analogy which we have constructed—can be used, like any analogy, to help us understand more about the motion of the marble (not to mention of motion in general) than we could have understood with out the aid of the analogy. Unfortunately, this is as much as we can say at this time about such mathematical models, since we have not yet developed a general understanding of this complex notion. In the last chapter of this text, however, we will investigate the logical underpinnings of such models, ultimately developing a mathematical model or analogy of Spacetime itself. After we have done this, we will be in a much better position to appreciate exactly what we have done here. Before that, however, we need to complete our investigation of Inductive Logic.



Roman Jakobson's Elements of Speech Events



Claude Shannon's Analysis of the Structure of Communication

Figure 3-1. Speech Functions and The Structure of Communication

References

[1] Today we know this text as the *Metaphysics*, even though (as is well known in philosophical cricles) the text *as produced* by Aristotle lacked a title. The accepted title, *Metaphysics*, is actually a corruption of an editorial title—*Meta to Physika*—that was given to the text after Aristotle's death. The interpretation of this "title", which literally means "*After the Physics*" and refers to the placement of the text in the Aristotelean corpus, is presumed to have been a misunderstanding of a Latin editor. Cf GBW, Vol. 8, p. 499.

[2] To which we referred in Chapter One, on page 16.

[3] Russell's designations are "knowledge *by* acquaintance", and "knowledge *by* description"; his source, however, had "knowledge *of* acquaintance" for the first type, which probably meant something like "the *knowledge* that is the result *of acquaintance*". As a result, Russell's variation is justified; and so here we shall use "knowledge of" and "knowledge about" for the two types of knowledge.

[4] Incipient Perception is nicely illustrated by people who, for instance, have been blind from birth but have received the "gift" of sight as the result of some medical/technical procedure. In many cases, the patient can "see" objects without actually understanding what they are seeing.

[5] Naturally, originary Perception merely changes over time (randomly, as does everything in terms of evolution); but of course the types of changes that persist are those that are evolutionarily advantageous, that do actually *improve* Perception, relative to the function of Perception—which is to allow for the *knowledge of* objects.

[6] The first humans—Home Habilis, of some 2.5 million years ago—almost certainly could not articulate the sounds of even the simplest of modern languages; at least, not if the placement of the hyoid bone means anything. But the next major form of humans—Homo Erectus, of about 1.8 million years ago—has a hyoid bone whose placement is almost identical to modern human—Homo Sapiens Sapiens.

[7] See, for instance, UCS, 1-3.

[8] Admittedly, of course, the process of communication *can* occur in both directions, in which case each end-unit would be called a Transceiver—a device that combines both a Transmitter and Receiver in one package. The human head, for example, is just such a "device", because it houses both our mouths and our ears, and this allows language to be communicated between two (or more) people in both directions at the same time. Nevertheless, the basic form of communication (especially in terms of our analysis) is one-way, as given in the diagram, and this is perfectly sufficient, not to mention more perspicuous, for our discussion.

[9] SIL, 26.

[10] For Aristotle's three "forms of persuasion" see, for example, RPA, 24-26.

[11] The most fitting example of the misuse of Semantic Analysis comes actually at almost the very beginning of Philosophy (indeed, some historians of Philosophy see it as *the* beginning), in the form of Parmenídes' poem on the nature of Being. There, the philosopher, who for this reason is often credited with having discovered Deduction, uses the meanings of the word Being (in its Greek form, of course) to determine the nature of the actual being of the Kosmos.

[12] As we saw in the previous chapter, David Hume acknowledged the fundamental relationship between Causality and Contiguity, and other, modern philosophers have done the same. See, for instance, SPC, 40-41.

[13] All data on Bacon comes from EOP1.235-39.

[14] Actually, the term Hume uses is 'priority' rather than 'antecedence'; in addition, he quickly (but not universally) replaces the word 'priority' with that of 'succession'. However, Hume it seems fairly obvious that what Hume really means is 'priority' rather than 'succession', and in addition the notion of succession has now become a component in the definition of 'contiguity' (which component this latter term lacked in Hume's day). Accordingly, I have avoided the use of the word 'succession' with respect to Causality, and have instead settle on the term 'antecedence', which (at any event) seems to bear out Hume's intention here.

[15] PNS, 16.

[16] This method for assessing analogical arguments is adapted from section 9.2 of EOL.