

Composition, context, contingency, comparison: four directions of movement in knowledge space

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Abstract

Various theories and typologies have tried to capture how researchers from different fields or traditions, encountering the same phenomenon, may see entirely different objects and questions worth exploring. Yet, existing typologies have not precisely articulated the process that, I believe, is most responsible for creativity within a field and opacity in interdisciplinary dialogue. I model this process as movement in knowledge space, which starts with the choice of a “direction” in which our gaze moves away from the phenomenon to be understood, to seek other phenomena that can illuminate it. In particular, I present four archetypal directions, which I call composition, context, contingency and comparison. These archetypes are idealizations of maximally different thinking styles, that I use to recognize and organize broader regularities across a continuum of scientific fields. The four archetypes differ in which features of the target phenomenon they bring in focus, and what they allow us to ask about it and do with it. I discuss various senses in which these archetypes can be seen as (i) independent research programs and ways of parsing the world, (ii) competing explanations for the same phenomenon, or (iii) complementary tools within the same explanation. My aim at this stage is to offer a simple, impressionistic model that a practicing scientist could use to expand their palette of moves for exploring the edges and interfaces of established fields.

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Research fields manifestly foster distinct thinking styles. More than just differences in language, objects or basic knowledge, these styles are what makes it difficult for an expert in one field to truly grasp what is an important question, or a beautiful answer, in a foreign discipline. Introducing a different style is also a major source of creativity within one field. Yet it is not easy to characterize these thinking styles, which are often learned as part of the tacit know-how of a research career.

When looking at two pieces of scientific discourse, there are many obvious ways in which they can differ: particular or general, precise or vague, concrete or abstract, causal or acausal, deterministic or probabilistic. I claim here that there is another way in which sciences differ, which plays a major role in the mutual opacity of thinking styles, and that this source of differences is strongly hinted at, but never precisely captured, by the many existing typologies and theories of knowledge.

My core metaphor is that we always understand a (target) phenomenon in the light of other (source) phenomena, but there are different directions in which we can move in knowledge space to seek these sources. For simplicity, all such moves will be called ‘explanation’, though they encompass a variety of concepts such as model, deduction or induction, metaphor or analogy. My aim in this work is to sketch out four archetypal directions of movement:

- zooming in (composition: what is it made of?)
- zooming out (context: what is it for?)
- looking back or sideways (contingency: what else could it be?)
- looking across (comparison: what is it like?)

Each one brings together very different fields and methodologies, yet captures some essential commonalities that make them more mutually intelligible within a type than across types. Without claiming that these four directions exhaust all the kinds of explanations there are, I believe that this model is an especially useful platform to think about both creativity and interdisciplinarity.

In Section 1, I isolate and define these four archetypes of explanation. In Section 2, I ask how they relate to each other (Fig. 2). Are they independent ways of parsing the world, yielding orthogonal concepts and phenomena? Are they competing to offer the best and most useful approach to any given phenomenon? Or do they come together like primary colors to compose any real, non-idealized explanatory discourse? Finally, Section 3 shows how the interplay of these archetypes helps identify, and perhaps solve, philosophical or methodological issues within each.

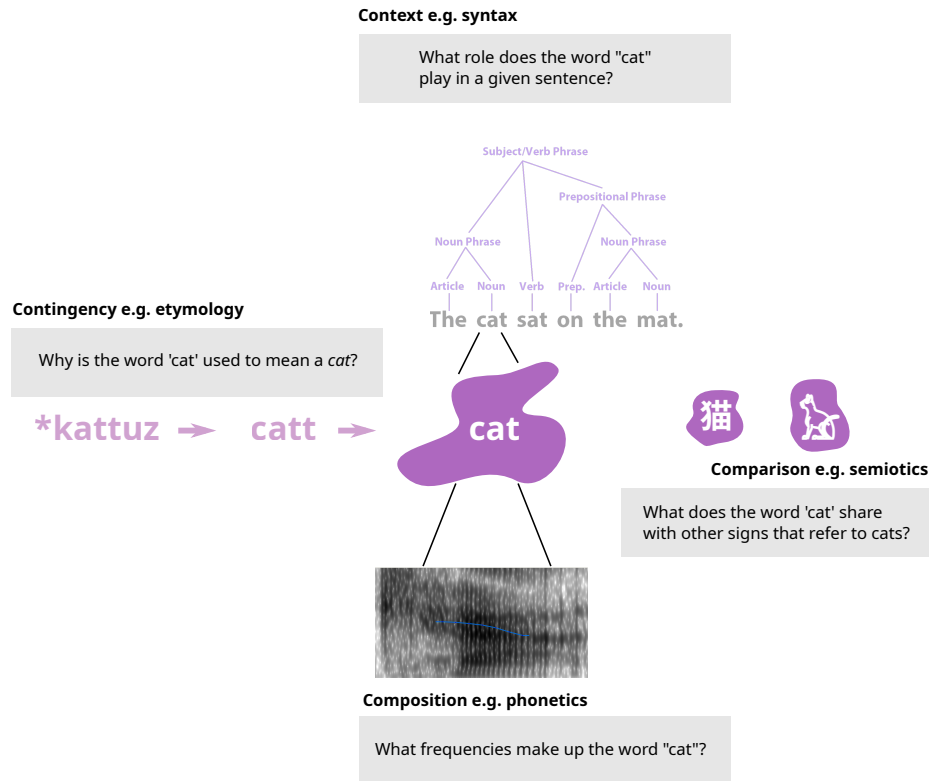


Figure 1: Four explanations targeting a single spoken instance of the word ‘cat’, corresponding to distinct sub-fields of linguistics, different types of questions and answers, and different equivalence classes of entities or phenomena.

1 A palette of archetypes

1.1 Case study of a ‘cat’

A single spoken instance of the word ‘cat’ in a conversation can be investigated in at least a few distinct ways, belonging to different sub-fields of linguistics (Fig. 1).

One possible type of question is: what are the elements that constitute the sound sequence ‘cat’? This belongs to the field of phonetics and phonology, where the sounds of language are explained in terms of phonemes, frequencies and formants.

A second type of question is: what is the role of ‘cat’ in the sentence “The cat sat on the mat”? This one belongs to syntax, where word order and agreement are explained by grammatical functions such as subject or object.

A third type of question is: why does ‘cat’ mean *cat*? The closest thing we have to an answer is the word’s etymology (it descends from another word

used to mean *cat*), where relations between sound and meaning are explained in terms of historical descent and possible mutations.

A fourth question is: what is shared or different between ‘cat’, ‘feline’, ‘neko’, a hieroglyph of a cat, and my perception of an actual cat. This touches on sociolinguistics and semiotics, where we isolate what is common to all these unrelated signs (the abstract *referential concept* of a cat) from what is not¹.

Notice that these approaches radiate in different directions – zooming in or out, looking back or sideways – to recruit other elements into an explanation of their target. They clearly lead to different paths of discovery, with distinct tools, questions and insights. Furthermore, they focus on different aspects of what may seem, *prima facie*, to be the same empirical reality. In some sense, these questions do not address the same entity or the same way of ‘carving the world at its joints’. This single chunk of speech can be understood as part of different equivalence classes: all the sound sequences that resemble ‘cat’ regardless of meaning or function (e.g. the first syllable of ‘catalog’); all the words that fit the role of subject in that particular sentence (e.g. ‘big red dog’ but not ‘flat’); all the historically-related cognates of ‘cat’ (e.g. French /fa/); all the signs for *cat* and their various connotations. Notably, we see that the entity of interest for etymology is a word, while the sound sequence and the syntactical subject could be smaller or larger units (a syllable or a phrase).

My goal in this article is to sketch these four approaches in idealized, archetypal forms, and use them as descriptive, comparative and creative tools for cross-disciplinary epistemology. This provides an intuitive sense for how various sciences diverge or converge in their concerns and methods by asking how their preferred ways of explaining resemble each of these archetypes. The example of linguistics makes such distinctions unusually visible, as the four can be illustrated by separate sub-fields, but I will also claim that these archetypes are present at all scales within any argument, model or theory.

1.2 A simple metaphor

I will think of knowledge metaphorically as movement in an abstract space of objects or experiences, somewhat in the spirit of Quine (1951). I will use the term of *explanation* in a much looser sense than is common², as any directed movement from known or assumed features of a source *Y* (explanans) to unknown or unassumed features of a target *X* (explanandum). This movement can serve to justify something that we know about *X*, or help discover something new about it; the latter will be more important here, as my foremost interest lies in how explanation empowers scientific creativity, rather than in the mechanics of justified knowledge.

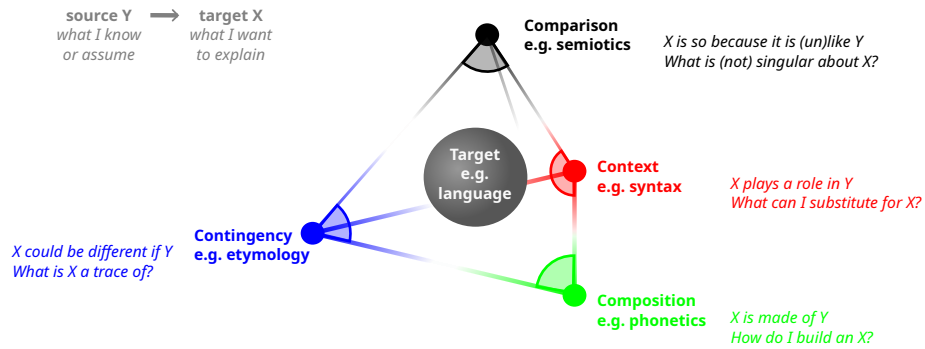
To help understand something about the target *X*, the source *Y* must typically be simpler (e.g. an atom), better known (e.g. a model organism³) or

¹E.g. style and register within English, cultural connotations of curiosity in English and luck in Japanese, while the hieroglyph and the cat itself sound like ‘miu’.

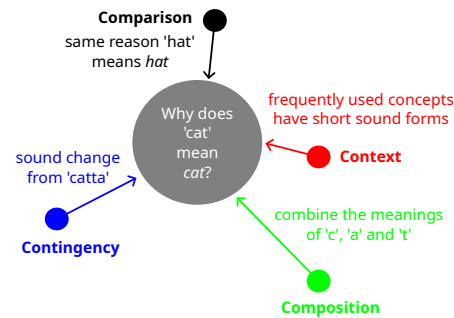
²See e.g. van Fraassen (1988) for a discussion of more canonical definitions.

³In Rosenblueth and Wiener’s words “the best material model of a cat is another cat or,

(a) Independent perspectives and questions



(b) Competing explanations



(c) Moves within an explanation

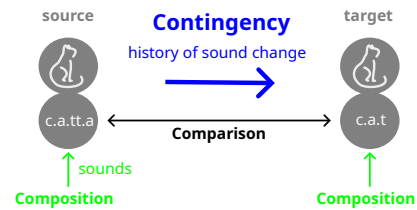


Figure 2: Four archetypes of explanation that can be seen as (a) independent sets of questions (examples in italics) about the same target phenomenon, as in Fig. 1, (b) alternative or competing answers to the same question, or (c) complementary ingredients and moves within a single composite answer (see main text for details).

easier to manipulate (e.g. a mathematical formula or a physical toy model). It need not have all of these properties at once: for instance, Y could be unknown and impossible to manipulate directly, yet assumed to be simple, like the atoms posited in physical and chemical theories before we had any evidence of their existence.

This definition of explanation is intentionally broad enough to include or evoke other concepts such as prediction, inference, deduction, induction, analogy or modeling, as I do not want to commit to any of these specific methodologies. For example, the formulation above is close to how *models* (e.g. a mathematical formula for a physical law, or a toy plane used to simulate a real one) are defined by Hesse (1963), yet both weaker and broader: weaker because the relation between source Y and target X need not be as tight and systematic as expected from a model; broader because it can be composite, drawing on a variety of sources at once instead of a single model object. The current section will focus on simple illustrations where a single source Y is mentioned, at the risk of blurring the distinction with models, but that will cease to be the case in later sections.

1.3 Explaining from different directions

Here, distinct *types* of explanation of X are different principled ways of searching for a source Y . As suggested in the introduction, this can lead to asking different questions and explaining different features of X . Each type empowers its users in distinct ways, but all types *explain* by staking a testable claim⁴ on which features should occur in X given some features of Y .

The four archetypes shown in Fig. 1 and 2 can be briefly stated and illustrated as follows⁵:

Composition: “the most relevant thing about X is that it is made of Y .”

Here, Y is a set of components, parts, substances or properties, and we use our knowledge of these components to explain something about the whole.

- A heart is made of cells, and therefore it can fibrillate.
- A Tang dynasty poem is made of pairs of lines with strong parallelism.
- A formal concept is made of properties and relations.
- Entropy is an aggregate metric over bits of information.

Context: “the most relevant thing about X is that it plays a role in Y .”

Here, Y is a better known setting, process or system that provides purpose or

better, the cat itself.” (Rosenblueth and Wiener, 1945)

⁴These claims are falsifiable and predictive at least in the broad sense of claiming that some observations should not occur or some actions should fail, if not in a narrower sense such as predicting future states of X .

⁵See Terminology issues in Appendix for a discussion of my naming conventions.

meaning to X ⁶.

- A heart serves as a blood pump in the body.
- A Tang dynasty poem was a demonstration of spontaneous creativity, and is now a demonstration of erudition, in games of social status.
- A smell is meaningful to me because it reminds me of my childhood home.

Contingency: “the most relevant thing about X is that it could be X' because of some Y .”

We point to events, states or features Y primarily to emphasize counterfactuals: what *is not*, yet *could be* (or could have been).

- This lightbulb will light up if we press the switch.
- The die throw could yield any number between 1 and 6.
- The words ‘cat’ and ‘gatto’ are related, as they come from same ancestor through different sound changes.
- The battle would have been lost if the general had not split the troops.

Comparison: “the most relevant thing about X is the way that it is like (or unlike) Y .”

Here Y is another unique object, of comparable scope and complexity, and we try to discover how statements that are true of Y are also true of X (or not), but these statements are only meaningful or discoverable within the frame of this comparison (Black, 1962).

- Western music differs from others in its codification of harmony.
- We expect mammals to respond to drugs in a way that can be tested in lab mice.
- Light is a wave like sound, except it has no medium.
- Parameters in the Navier-Stokes equation correspond to the viscosity of fluids.

For now, I hope that some sort of Gestalt can emerge from this impressionistic first pass through all four archetypes, but I will strive to define them more clearly throughout this work, and briefly consider how they connect to established epistemological theories in a later section.

⁶In compositional terms, we are explaining features of a part based on something we understand about the whole

1.4 How to isolate each archetype

For the purposes of this section, I treat each archetype as independent and monolithic, pictured as poles in Fig. 2. The simplest way of distinguishing one of them is by trying to negate all the others.

Composition is what is left when we extract X and study it in a vacuum, removing it from its peers, its context and history. I call *components* (the sources Y of the explanation) anything that can still be observed in that situation: these could be physical parts localized in space and time (i.e. things that exist by themselves), but also more abstract qualities and properties such as color or symmetries.

Context is about the place that X occupies in a system Y , the hole that remains if we remove it, that has nothing to do with what X is, where it comes from or what it is made of. Playing the *role* of an organ in a body means being one of the objects that, regardless of their composition or history, can successfully occupy that position in that context (including e.g. artificial pumps or valves or pacemakers). The proof lies in some test on the system Y (e.g. does the body still live, is the sentence grammatical, is the computer program running?), not in the identity or implementation of the object X .

Contingency is about *accidents*, i.e. what is left when we remove all the features that feel truly tied to the object itself. The fact that a flower pot fell on my head seems to speak neither to my identity, nor my biology or role in society; intuitively, it is an independent causal chain meeting mine, which could have happened or not for the same me⁷.

Comparison differs from the other archetypes in that the latter all assume what each object is, and how they relate (part or function or accident), whereas true comparison is what happens when we set two phenomena side-by-side without any prejudice and strive to discover *in which ways* these two phenomena are the same or different, and thus define their *identity*.

1.5 How they are used

Another motivation for distinguishing these archetypes so starkly is that they can be associated with distinct scientific practices, both in terms of how we analyze phenomena, and of how this analysis empowers us to draw novel inferences and act effectively in the world.

Composition empowers us to assemble a copy of X , or to target, extract, purify and reuse its parts. It can relate properties of the whole to properties of the parts, e.g. defining macroscopic temperature in terms of microscopic particle velocities. It encompasses both practices where we focus on the nature of each part (e.g. chemical formulas) and practices where we focus on their relations (e.g. electrical diagrams).

⁷I will later discuss cases of contingency where the notion of strict identity between X with and without accident is relaxed to some broader notion of equivalence, such as the counterfactual scenario of being born to other parents than one's own, which clearly has some impact on identity.

Context empowers us to assign meaning and purpose, replace X by an ersatz or identify redundancies (X and X' playing the same function), and study its adaptation in a new context Y' . This type is much more developed in a design setting where purposes are unarguably real and known, e.g. for engineering or software architecture.

Contingency empowers us to consider counterfactuals (“what if”) across time, space and replication: it provides tools to predict and retrodict, to define forks and causality⁸. I will argue that it uses similar concepts to address causally-related phenomena (e.g. descent) and causally-unrelated ones (chance).

Comparison empowers us to identify objects and transfer knowledge from one to another. It relies on making judgments of identity, similarity, Gestalt or ‘family resemblance’, and their counterparts, judgments of contrast and uniqueness. We do not wish to assume *a priori* how objects are to be analyzed into features and compared: only by bringing them together can we deduce which details on each side are meaningful for their description (Black, 1962; Smith, 1990). We can then explain a particular feature of X by its global similarity to a Y that has the same feature, or global dissimilarity to a Y that does not have it (e.g. this cat has legs like other mammals, and unlike fish).

1.6 Final notes on the palette

Though I briefly sketched how to distinguish these four archetypes, equally important is what does *not* distinguish them: explanations of all types can be general or particular, concrete or abstract, formal or informal, synchronic or diachronic, etc. Variants on both sides of this dichotomy can be found in each archetype, and some are discussed in later sections.

The previous two sections also aimed to hint at the origins of interdisciplinary opacity. First, researchers drawing on different archetypes can feel as if they are talking past each other: each set of questions can potentially be isolated from the others. Second, a researcher trained in using an archetype can feel that other practices are sterile: they do not provide the means of acting, upon knowledge or upon the world, that the researcher is used to employing and valuing.

2 How the archetypes relate

So far, the four archetypes have been described as largely independent sets of practices and ideas that we can bring to bear to gain knowledge about a given phenomenon (looking at its composition or context, identifying its contingent features, or comparing it to other objects). Now I start from the opposite extreme, discussing whether they might be completely entangled everywhere, i.e. whether we can only understand a target phenomenon by combining sources and moves from all four (and perhaps more) directions.

⁸Pearl (2009) proposes to distinguish causation from correlation precisely through a (somewhat mysterious) ‘Do’ operation, a contingent action that comes from outside the rules and relations of the study system, such as a human agent performing an experimental perturbation.

2.1 Case study of a physics problem

In a physics problem, the explanatory power of a theory manifestly stems from the compositional perspective: knowing the atomic parts of the system and their rules of behavior, sometimes called ‘bulk equations’ for particles or for points in space-time (e.g. Newton’s laws of mechanics, or the Navier-Stokes equation of hydrodynamics), which combine to give rise to system-level phenomena.

Yet, informal judgments of analogy pervade any application of this theory, to know how various parts of the equations relate to various measurable facets of physical phenomena, and to decide that we are looking at objects sufficiently like particles or water to apply mechanics or hydrodynamics rather than other theories. We must also specify (i) boundary and (ii) initial conditions: (i) how the system is defined by, and in contrast with, its external environment (context: what is the shape of its border, and is there energy or matter crossing in from outside?) and (ii) in what state it happened to be when we started looking at it (contingency). These conditions are often explicitly said to ‘select’ one solution among those allowed by the bulk equations.

In a purely logical sense, all of these facets (equations, boundary and initial conditions, having identified the right model and parameters for the system – composition, context, contingency, comparison) play an equal role in determining the final conclusion, which would be different if any of them were changed. Yet, in physics, the equations feel general and justified by deep theoretical arguments, while the boundary and initial conditions are provided in an *ad hoc* fashion, adaptable to every particular example one encounters, possibly guided by some technical ‘know-how’ but typically not considered part of the core dogma, and taught via practical exercises rather than as laws or theorem. These conditions may even be minimal or ‘void’, which is an explicit way of negating the importance of a given explanatory direction. For instance, the simplest boundary condition is isolating the system from the rest of the universe, voiding the role of context; whereas in an equilibrium problem, we assume the same state is reached from any relevant initial condition, voiding the role of contingency.

Thus, the importance of a type is not tied to its logical influence on the conclusion, but to the way it shapes the kind of question asked and explanation provided. I will claim that there is always a single *defining type* that provides the overall thrust and style of the argument, by stating which are the main sources *Y* to be used *and* what we are trying to understand about target *X*, while other types are instrumental in that goal.

2.2 The case for orthogonality

Starting with orthogonality, some questions arising in one explanatory type are clearly meaningless or eliminated in the other approaches. In fact, as noted above, one can try to actively isolate one of the types by voiding the others, either conceptually or in practice. Picking up an object and isolating it in the artificial vacuum of a laboratory allows us to more easily ask a certain kind of compositional questions, but immediately voids our ability to ask questions

about its place in its natural context.

The features that different explanatory types reveal about the same object X can be entirely orthogonal in that sense, yet still correlated in practice. For instance, what an object is made of (say, a steel hammer) *does* limit the roles it can play (weapon or tool), or the histories it may have (post-Bronze age), but that relation is far from tight. In English grammar, a noun can fill the role of the subject or object but never serve as a tense marker, while the subject function could be played by a noun or a phrase but not a determiner⁹.

Thus, the questions and objects that we encounter in one thinking style or another are likely never entirely independent of each other, but they vastly *underdetermine* each other, existing in many-to-many relations.

This guarantees at least a degree of independence between these explanatory types. They need not compete for metaphysical priority, and even if we commit to one, others remain at least pragmatically valuable in the generation of novel questions and insights. We may believe a single explanatory type to be more fundamental – for instance, we may think that simulating the physics of the entire universe by breaking it down to elementary particles would in principle yield the only true model of everything – yet the others can still inspire almost orthogonal sets of properties and questions. Our speculative universe simulator could dispense with ever asking about word meanings or grammatical functions, yet that does not render these questions uninteresting, as they manifestly guide scientific inquiry.

2.3 The case for competition

We could also see the archetypes as ‘competing’ and ask: in which direction should one search for some source Y in order to find the most interesting questions about target X , or to most clearly and efficiently answer a given question? I will distinguish these two arenas of competition, and offer criteria to help decide which archetype should ‘win’ (e.g. it invokes better sources, and is less likely to mislead us).

The first arena is competing for what questions to ask about the same object. Different questions may be more or less fertile: for instance, trying to predict the precise trajectory of thrown dice may be a less fruitful endeavor than asking about their probability distribution. These questions are not mutually exclusive, and thus not competing in the strict sense, but one may still prevail in practice.

The second arena is competing for how to answer the same question. A given question can sometimes be asked from the perspective of several explanatory types, each starting from a different source to construct a different explanation. These answers could be mutually exclusive or not, but it is likely that one will be more accurate or usable than the others.

⁹For a more abstract example: information theory (which is primarily compositional and largely simplifies or discards context) cannot tell us which meaning *is* stored in a certain configuration of bits, but it can tell us which meanings *cannot* be stored in it because they require a larger capacity. We do not know if an encrypted hard drive actually contains the text of Hamlet, but we could know if it is too small to contain it.

My intuition here is that, once the target is precisely defined, one of the four directions will more easily yield a productive source of knowledge. Here, a ‘bad’ choice of source would be one that is not truly simpler or easier to understand or manipulate than the target X , one that does not lend itself well to being measured or adapted to new applications¹⁰. As illustrated in Fig. 2(b), the only good answer for why ‘cat’ means *cat* in English is found in the word’s history, tracing the pairing of sound and meaning to older language states, because it is most effectively described as a fundamentally accidental relation, one that cannot be simply deduced from the phonemes that compose the word, nor from its role in the broader English language (e.g. in relation to ‘bat’ or ‘dog’ or other words).

We *can* in principle ask about the sound-meaning relation from the point of view of context, e.g. sociolinguistic reasons that led to one form becoming more popular than another. Yet a complete account from that perspective, or from acoustics and neuroscience, seems much less practical than simply tracing the word’s lineage and cognates. The other archetypes usually come second, to add some nuance to a mostly-correct perspective of pure contingency¹¹.

We may thus work to identify which type leads to the most immediate and fertile explanations in a given situation. It is not surprising, for instance, that the heart was understood as a pump long before we could analyze its structure under a microscope or understand its evolutionary history: zooming out to the whole body requires much fewer inferential steps and complications than zooming in to tissues or individual cells and mapping out their interactions, or doing comparative anatomy across evolutionary lineages. Likewise, political science is not (yet?) practically approached by simulating the mind and actions of every human being on Earth, because such minds and actions are, for all practical purposes, not better understood nor more regular than the political facts we are hoping to explain.

2.4 The case for instrumentalization

While it is useful to treat archetypes as different research programs or thinking styles at a ‘macroscopic’ level, I already noted that any real explanation will involve all of them in some way. My examples of ‘pure’ archetypes above are simply ones where these other contributions are less apparent, because a single facet carries the main thrust of the explanation while the others are ancillary.

My position is that any subfield of knowledge is biased toward a single archetype that defines the kinds of questions and answers it judges to be truly meaningful, but any intellectual effort uses tools and practices associated with all archetypes. Intuitively, we appeal to composition when we analyze a contin-

¹⁰I strongly suspect that many of what we currently call ‘complex systems’ are systems that we insist on studying through a prism that is not fit to yield the simplest, clearest explanations, and propose to demonstrate it in future work.

¹¹Such second-order corrections, e.g. sound symbolism from the Kratylos to the Bouba/Kiki effect (Ramachandran and Hubbard, 2001), should not be taken as serious challenges to the first-order regularity that is the arbitrariness of linguistic signs.

gent history as a list of events, or a context as a set of environmental factors; we appeal to contingency when we ask what would happen to an organism if we replace an organ by another; we appeal to context when we compare a particular object to a broader class it belongs to, etc. It is impossible to even describe or define an archetype, as I did above, without using concepts or tools that belong to another.

Yet it is worth noting that using a certain tool does not automatically affect the overarching explanation. Any list or enumeration is intrinsically a compositional tool (it defines something by going through its parts), but lists are used in many different forms of knowledge without drastically influencing the nature of the questions or answers. In some cases, however, this leads to true hybridization and the emergence of novel concepts, which I discuss at length in a later section on creativity and dissonance.

2.5 Different explanations of explanation

There are two ways that we can apply this framework to describe epistemology itself: the content-level question (what do other theories *claim* about knowledge; do they liken their objects of study to only one of the archetypes listed here?) and the meta-level question (how do other theories of knowledge *function* as explanations; are they themselves behaving as one of the archetypes would suggest?).

At the content level, various epistemological theories can be understood as systematizing one of the archetypes above as their primary representation of knowledge. Interventionism (Woodward, 2003) is primarily contingency-oriented: to explain X is to identify factors that, if intervened upon, would change X. Mechanistic explanation (Machamer et al., 2000) is primarily compositional, as Bechtel and Abrahamsen (2005) define mechanism as a “structure performing a function in virtue of its components parts, component operations, and their organization”. Hesse (1963) and Kuhn (1962) clearly focus on comparisons and analogies, both pairwise and toward exemplars. Constitutive explanation, e.g. “temperature *is* kinetic energy” (Dasgupta, 2017) is a strict form of comparison that goes to total identification. In each of these cases, other archetypes are considered explicitly or implicitly, but one is clearly more central. This suggests that each type, when taken as primary, generates a coherent philosophical account.

Returning to the meta-level question: how does an epistemological theory *itself* function to explain explanations? For instance, most of the theories listed above are compositional: they are trying to decompose explanations (e.g. into an exemplar and ways to connect to it, for Kuhn). Pragmatic and sociological theories of science are contextual at that meta-level: contrary to the above, they focus less on the form and content of explanations, and more on their place in a larger discourse (Bloor, 2004). van Fraassen (1988) favors contingency, focusing on how explanations would be different from a different perspective.

Quite transparently, at that meta level, my work here is *comparative* first and foremost. For the most part, I treat explanations as particular objects and

draw analogies between them (Hofstadter and Sander, 2013), mainly through judgments of similarity to archetypes. One characteristic of this comparative type is its horizontality: while some particular objects are used as archetypes, they are not thought to have true anteriority over others. I have refrained from organizing explanations into genealogies or hierarchies (e.g. claiming that mathematical explanations are more abstract while physical ones are more concrete, or that some concepts are metaphysical primitives), and I thus try to avoid giving primacy to one archetype, as I argued is the case in the various families of theories above.

The potential success of my comparative approach hinges on a practical question: does drawing analogies between these diverse explanatory practices illuminate details that were not as visible before? My main hope is that the various questions that arise throughout this endeavor, from archetypes to relations to evaluation criteria to modes of hybridization, will prove their worth by enabling reflexivity and creativity in other scientific endeavors.

2.6 Why these four

I now try to address two questions: In which sense do these four archetypes exist on the same level, and are they the only four possibilities?

The first question admits a deflationary answer: as part of my stated comparative stance, I am actively choosing to treat these four archetypes horizontally. In science, reasoning from exemplars (the pendulum) or model organisms (the lab mouse) does not impose any ordering between objects: a model mouse is more complex than a model worm, but that is just one of many ways in which they differ, without the worm being more fundamental. Likewise here with these four exemplars: they may be more or less established and complex in the current state of various sciences, but all four can be used as equally different vantage points.

These four perspectives are each holding something constant or prior to the rest. Comparison holds our experience of objects as prior to their identity and features, which emerge only when juxtaposition reveals what is the same or not between two objects. Contingency holds constant the identity of the object and asks what else it could be, by relating it to other phenomena that we call accidents. Composition is about everything that is part of that object in the sense that it forms a constant web of relations, that stays with the object as it moves. Context holds the position or role as prior to the object that currently occupies it, as it could be occupied by something else.

Another question is: why (only) four? Many typologies offer fewer or more types, although there is a heavy historical precedent in Aristotle's four causes¹². My personal intuition is that the four types I listed constitute the most

¹²Only a serious scholar could judge whether the latter relate in any meaningful way (if only genetically) to my archetypes, but as a pure thought experiment, we could try to map material cause to composition, final cause to context, efficient cause to contingency, and formal cause to composition+comparison to see if this generates useful intuitions. One virtue of this thought experiment is that associating the formal cause with 'Gestalt' judgments of similarity feels

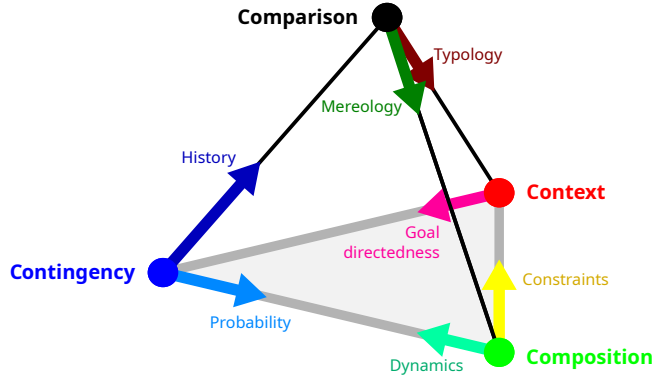


Figure 3: Hybrid explanatory types have their own logic and practices, yet they can usefully be analyzed by invoking the four archetypes of Fig. 2 in either defining or instrumental positions. Some hybrids are shown here as arrows pointing from one pole, which defines the overall flavor of the explanations (what is explained from what), toward another pole that provides a central tool: for instance, probabilistic explanations are a subtype of explanations from contingency which relies on a full compositional account of the space of possibilities, whereas for historical explanations, this space is unknown *a priori* and each possibility is a heterogeneous accumulation of facts discovered through comparison to other (real or counterfactual) particular trajectories. All these hybrids are mentioned in the main text or in Appendix, but only a few are detailed.

distinct poles among styles of explanation in the natural and social sciences, the ones that capture the deepest forms of variation.

Many more distinctions could be made between kinds of knowledge: are they formal or narrative? Particular or general? Ordered or unstructured? Predictive or *a posteriori*? All four archetypes have variants that fall on either side of all of these dichotomies. The question of how the *explanans* and *explanandum* are related seems, to me, more structuring at the level of fundamental intuitions. Particular and general compositional explanations (e.g. a singular DNA code versus general information theory) may appeal to different scientists, but they are still largely mutually intelligible, in a way that a compositional and comparative theory are not.

germane to the relative opaqueness of this cause, which seemingly requires us to characterize what an object is *prior* to any elicitation of what it is made of, how or what for (Falcon, 2023).

3 Crossing dimensions

3.1 Generality and particularity

As I started hinting above, there is at least one striking source of differences between thinking styles that fits in my model of movement in knowledge space, but has not been addressed yet: interest in general or particular explanations. Conversations between collectors of singularities and believers in universality are notoriously difficult, and both kinds are manifestly found in each field though in very different proportions.

In my model, maximally general explanations are those that use the same sources to understand many different targets, whereas maximally particular explanations require identifying the correct sources *de novo* for each target. This property is therefore logically independent from any of the archetypes, which instead characterize the direction of movement, i.e. the kind of relation connecting source and target.

It is worth spending some time illustrating it, as that will provide the opportunity to offer a more nuanced picture of the four archetypes. I will not delve deeper into the possibility of general explanations that cross between archetypes, using the same source in different directions, though there are certainly notable examples¹³.

3.1.1 Generality in composition

General compositional explanations require many targets to arise as combinations of a small set of consistent, well-defined components or properties that are independent of context and history. Subatomic particles are ideal components in this respect because their types are few, differ in very few ways and follow the same rules everywhere. Phonemes are rather good, cells are tricky and animals even worse. Still, some phenomena depend only on a much smaller and more universal subset of properties of their components, allowing general compositional explanations to work even with complicated ‘particles’. For instance, we can model crowd behavior compositionally with a certain degree of success, even though human beings are very far from being elementary particles, because only their positions, velocities, and simple ‘forces’ turn out to play a large role in shaping that particular phenomenon. Thus, what matters is indeed that *relevant properties* are few and context-independent, and not necessarily that the components themselves are simple.

Particular compositional explanations are equally meaningful and useful. Technical manuals (or their biological equivalent, exhaustive descriptions of cellular and molecular components of an organism) may list many unique parts that are not necessarily reusable in a different machine, but may at least be identified, extracted, repaired or replaced.

¹³E.g. in biology, reproduction and mortality serve as a selective context for individual organism features (they define their role and purpose), but as a component of ecological dynamics at the population and ecosystem level.

3.1.2 Generality in comparison

Comparison is unique in that it can be used symmetrically, swapping source and target between two objects (although see Inverse problems in Appendix). It behaves more like other modes when we relate one target to many sources (e.g. describing an individual culture by its contrasts to many others), or many targets to one source (e.g. using a model organism to inform the biology of many others), which are its ways of emphasizing particularity or generality.

General knowledge can arise from special sources, such as model organisms or archetypes (as in this very article) that have been identified as particularly useful points of comparison for many targets. For instance, Kuhn (1962) argued that much of normal science proceeds not by applying general rules, but by recognizing that a new problem resembles a solved exemplar, such as the pendulum in mechanics. These models are, ideally, both thoroughly described, and associated with an entire corpus of practices and tools aimed specifically at transforming this knowledge into insights about other objects. They are thus perhaps less thoroughly ‘reinvented’ during the process of comparison than in the other cases, yet their description keeps being enriched by each successful explanation they participate in.

Any particular description of a target object, e.g. when describing a person or a culture and trying to characterize its singularity: this implies a comparison to a background of many source objects, which guide us in deciding what even constitutes a feature to report¹⁴. This is associated with the practice of accumulation or ‘thick description’ (Geertz, 1973): because we do not know in advance which details will matter, the more unique things we can say about any object, the more defined it is as either an explanatory source or target, to assert either similarity or difference. This culminates in *naming*, whether labelling species or drawing ontologies¹⁵, since a unique name is a handle that points at all the particularities we know and those we have yet to discover (Montévil, 2019).

3.1.3 Generality in context and contingency

By now it should be easier to extrapolate what it means for each archetype to be used in general or particular explanations, so I will move rapidly through the last two.

For context, a maximally general methodology would derive all roles and purposes from a single universal process or drive, be it natural selection or God. Darwin’s foremost contribution was indeed not having noticed adaptation, but having claimed that a single selection criterion, reproductive success, underlies all others (which can notably explain maladaptation). Outside of this example, for cultural reasons laid out by Descola (2005), there is a Western tendency to

¹⁴Sciences of the particular are usually ‘piecemeal’ in the sense that the arguments they invoke in one case may not be reusable in another. This explanatory type therefore seems to fight back against formalization, except through hybridization with other types, as detailed in later sections.

¹⁵Ontology is taken here as in informatics and knowledge representation, i.e. a setting-specific net of verbally-defined concepts or entities and relations, such as a database ontology.

interpret purpose or meaning as mental concepts and intrinsically particular: what a specific object or event means for each person is singular to their own perspective, as in the classic Rashomon story. Even a particular contextual explanation can nevertheless be made operational, e.g. the last native speaker of a dying language can still be interrogated to make sense of words in their language.

For contingency, general forms include probability theory and genealogy, that try to capture universal structures in certain kinds of accidents (in synchrony or diachrony), as I detail in the next section. Historical narratives (whether human or natural, e.g. geology and biogeography) are obviously more particular, but they show various degrees of systematism: the history of mentalities investigates population-wide changes in representations (Burguière, 1982); a ‘great man’ theory will focus on decisions made by a few individuals in power; a maximally particular explanation will invoke an arbitrary mix of causes of very different natures, e.g. the outcome of a battle is the confluence of weather, terrain, logistics, troop morale and the personality of the commanding officers. At the extreme end of particular contingent explanations, the accidents Y might not be understood or described in any way beyond their identification, e.g. we can simply write a chronology of named events.

3.2 Instrumentalization, creativity and dissonance

Finally, my goal here is to show that recognizing these archetypes and their interactions is useful to identify, and perhaps solve, methodological or philosophical problems.

My core intuition is that drawing on tools from one archetype to answer questions from another is a key source of creativity, but can also cause a deviation from the original questions, and I now provide examples of both kinds.

3.2.1 Comparison and others

I start by discussing how comparison can instrumentalize each of the other three archetypes, or all three together. Comparison based on composition yields mereology: we judge two objects X and X' to be more similar if they have more similar parts (e.g. H_2O , H_3O^+ and HO^- molecules being made of the same components), or more similar relationships between parts (e.g. sound and light and the d’Alembert wave equation all display similar relations between properties such as frequency, wavelength, velocity, energy, phase, etc.) (Hesse, 1963).

Comparison based on contingency yields a notion of relatedness between X and X' , i.e. how many accidents they have in common. The most intuitive case is shared descent: cognate words or related species are those that are nearby in an evolutionary tree because they share many common ancestors or branching points from the root. This kind of similarity evokes persistence in the sense of the ‘ship of Theseus’ story, where the ship’s composition changes across repairs, but is linked by an unbroken chain of events. Two perfect clones of the same

human set in identical situations may have the same composition and same context, yet they differ by contingency (the accident of having been born clone A or B, being a different branch in the tree), which forbids a total identification.

Comparison based on context yields notions of functional similarity and redundancy: equivalence classes between entities that can be substituted, e.g. hearts and mechanical pumps, corresponding to functional roles within a larger system. A minimal case of the latter is typology, where the only role played by each part is belonging to a class. But to make it operative, we usually need an additional compositional description of the class: we define it in terms of properties, which are inherited through membership, e.g. a cat has four legs because it belongs to the class of cats which is a subclass of mammals which is a subclass of tetrapods.

Typology immediately runs into the problem of exceptions: if cats are defined as having four legs, a cat without legs is a paradox. Adding concepts from the contingency archetype dissolves that issue: we can see this cat as a typical cat to which we added the contingent feature of having lost its legs. It is thus a member of the category of cats *plus* accidents, rather than *minus* defining features of that category, it being crucial that this entity historically had or counterfactually could have had legs, in order for it to be rightly classified as a cat.

We might then conclude that comparison needs to draw on all three other archetypes to function: for two entities to be formally the same, they should share every compositional, contextual and contingent feature. A biological example is model organisms: it is because their anatomy, ecological function and evolutionary history are all together representative of a broad range of lesser-known organisms that we can hope to transfer particular inferences (such as the efficacy of drugs or conservation measures) from one to another. Yet, trying to exhaust the object of observation as a list of features goes against the principle of the comparison archetype.

3.2.2 Contingency and others

Theories of contingency usually draw on composition for their formal apparatus. Probability theory requires us to be able to enumerate the entire set of counterfactual possibilities (e.g. every possible result of a dice throw). In other words, it invokes a full compositional description of the space of alternatives, in order to explain something about the contingent outcome that was eventually observed (its probability). For some compositional spaces, an unstructured enumeration of possibilities is enough (e.g. the values of a coin toss). Others are defined by their structures, such as order and continuity in a chain of events, from causal graphs (a fire would trigger a sprinkler that would make the floor wet) to chronologies or stratigraphy in geology and archaeology.

Less theoretical contingency-based explanations usually draw more on comparison, and less on composition, for their tools: history is often implicitly or explicitly comparative when it tries to articulate important forks in the road, even if it cannot ever enumerate all the possible but unobserved alternatives.

This open-endedness of uncountable alternatives may also be a defining trait of biology as compared to physics (Montévil, 2019), and a problem with the use of probabilities to describe living beings.

There is in fact a deeper philosophical dependency of contingency on comparison and its judgments of identity or equivalence. For counterfactual historical narratives, we cannot ask what X would be in a different world without assuming that we can meaningfully think of it as “still X ” somehow. Probabilistic thinking also relies on assuming an equivalence class: all dice throw are, in some sense, different realizations of “the same event”, which is what allows us to use their frequencies to define the probability of any single event. This becomes much more problematic when thinking about the probability of an election being won by one party or another, which is always a unique event. The intuition that it is possible to have multiple versions of the same thing underlies the very notion of *accident*.

This ties together causality, historicity and randomness as facets of contingency: history focuses on the descent and potential forks in one causal chain, randomness on the accidental collision of independent chains, and accidents are necessary to even define a direction of causality and time (Falcon, 2023), see also Appendix.

3.2.3 Context and others

The most widely used empirical tools to investigate the purpose, role or function of some object X in a larger system Y are *deleting* X , or *substituting* another object X' in its place and checking how that affects Y . For instance, we can replace a biological heart by an artificial pump and check whether the organism can keep living. This is a clear invocation of contingency: we are asking (and answering) the question of what would happen if we were to create a counterfactual organism without a heart or with a different one.

Analogous practices are found in linguistics, neuroscience, engineering and so on. These practices are in fact essential to ensure the autonomy of contextual explanations in many fields: we do not need to understand the full structure or evolutionary history of X or Y to perform such tests; knowing nothing else about an organism, we can still check “from the outside” whether it is still alive, able to reproduce, able to move, etc. as we remove some of its organs or substitute some of its genes.

Ultimately, the very same tools produce an understanding that is deeply rooted in comparison: when we identify the heart’s role in an organism as a pump for blood, we mean both (1) that it is part of the equivalence class of all objects that, regardless of their structure or history, can successfully occupy that position in that context, and (2) that we can understand much about the heart by comparing it to an archetypal pump.

3.2.4 Composition and others

In many fields, the composition of an object X is revealed through repeated comparison with other objects X' : for instance, the list of phonemes in a word or in a language can be extracted through pair comparisons, to understand which sound differences are or are not meaningful. More abstractly, we can use comparison to transfer compositional understanding from one object to another: when we relate a physical phenomenon to a formula by matching their parts, each variable or coefficient in the formula corresponding to a different measurable physical property, we gain compositional understanding about the physics from our compositional understanding of the mathematics. Finally, as I noted above, a constitutive explanation such as ‘gas temperature *is* the kinetic energy of the molecules’ (Dasgupta, 2017) is a strict form of comparison between properties of the whole and properties of the components that ends in total identification, i.e. the property of the whole ceases to be considered as an independent phenomenon and is completely dissolved into the properties of the parts.

Another key method to understand the composition of an object is by employing contingent “accidents” in the form of experimental perturbations, manipulations, etc. The underlying intuition is that I defined composition above as a web of parts and relations that stay attached to the object of explanation (physically when we isolate it in the lab, or metaphorically). One way to test this is to prove that these relations are indeed causal rather than only correlative.

This focus on causality, while deeply ingrained in how we think about physics or chemistry, is not actually necessary for many subfields of these sciences: equilibrium and structural properties, such as electrostatics, crystallography or stoichiometry, are typically expressed purely in terms of composition and constraints, and were understood in that way long before we had a causal dynamical model of how they come about.

For readers familiar with Conway’s Game of Life, it provides an interesting example of a dissonance between the two archetypes in a dynamical model. This game aims to fascinate by showcasing the emergence of very complex life-like behaviors from simple compositional rules. Yet what essentially allows these complex behaviors is the judicious choice of the initial state of the cellular automaton, which is imposed in an *ad hoc* fashion by the programmer. Almost every possible initial condition leads to uninteresting dynamics. Interesting initial conditions are “handcrafted” and discovered through labor-intensive human exploration. In brief, the Game of Life purports to exemplify the wonders of compositional emergence, when the actual work is setting up the correct contingent starting point.

4 Conclusions

The purpose of this article was to show that, although the four archetypes I propose are far from entirely novel, treating them as equal vantage points on

any potential target of knowledge, and understanding their interplay as competitors or tools, yields a useful map of philosophical problems and scientific opportunities.

I have argued that different archetypes can be seen as orthogonal, competing, or complementary at different stages of the process of understanding (Fig. 2). The four directions are orthogonal when we are *adjusting the target*, i.e. converting a bare phenomenon into an object of knowledge: each archetype will yield a different way of parsing the world into meaningful objects and questions. Competition arises when we are *adjusting the source* for a well-defined target: regardless of how we arrived at an object, it may be better understood by using certain sources, and we need criteria to define that notion of “better”. Finally, once the target and source are selected, we need *tools to bridge them*, which may involve borrowing concepts and methods from all archetypes.

I believe that many other philosophies of science would recognize at least some of their insights in this work, if not necessarily the value of arranging them as I did; likewise, many scientists would recognize these archetypes in their tools and subfields: biologists, for instance would readily have a sense of where to fit anatomy, evolutionary history or molecular biology. As far as I know, the closest antecedent to this work is Pepper’s World hypotheses (Pepper, 1942), a similar-looking set of four types¹⁶ that are assumed to be mutually incompatible, whereas I propose that hybridization is often creative, though occasionally dissonant.

My hope in this work is not just having produced yet another typology, but a simple tool to point at what I think are the most important causes of opacity, misdirection and novelty within and across fields, which I plan to demonstrate by using it in future research and interdisciplinary dialogue.

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References

- Albert, D. Z. (2000). *Time and Chance*. Harvard University Press, Cambridge, MA.
- Barbier, M. (2026). Inventing a formal language of telics. In preparation.

¹⁶I only encountered them after developing this classification, and will mainly note that his “contextualism” is closer to my “contingency”.

- Bechtel, W. and Abrahamsen, A. (2005). Explanation: A mechanist alternative. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, 36(2):421–441.
- Black, M. (1962). *Models and Metaphors: Studies in Language and Philosophy*. Cornell University Press, Ithaca, NY.
- Bloor, D. (2004). Sociology of scientific knowledge. In Niiniluoto, I., Sintonen, M., and Woleński, J., editors, *Handbook of Epistemology*, pages 919–962. Springer, Dordrecht.
- Burguière, A. (1982). The fate of the history of mentalités in the Annales. *Comparative Studies in Society and History*, 24(3):424–437.
- Dasgupta, S. (2017). Constitutive explanation. *Philosophical Issues*, 27:74–97.
- Descola, P. (2005). *Par-delà nature et culture*. Gallimard, Paris.
- Falcon, A. (2023). Aristotle on causality. In Zalta, E. N. and Nodelman, U., editors, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, Spring 2023 edition.
- Geertz, C. (1973). Thick description: Toward an interpretive theory of culture. In *The Interpretation of Cultures: Selected Essays*, pages 3–30. Basic Books, New York.
- Hesse, M. B. (1963). *Models and Analogies in Science*. Sheed and Ward, London.
- Hofstadter, D. R. and Sander, E. (2013). *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking*. Basic Books, New York.
- Kuhn, T. S. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago.
- Machamer, P., Darden, L., and Craver, C. F. (2000). Thinking about mechanisms. *Philosophy of Science*, 67(1):1–25.
- Montévil, M. (2019). Measurement in biology is methodized by theory. *Biology & Philosophy*, 34(3):35.
- Pearl, J. (2009). *Causality: Models, Reasoning, and Inference*. Cambridge University Press, Cambridge, 2nd edition.
- Pepper, S. C. (1942). *World Hypotheses: A Study in Evidence*. University of California Press, Berkeley.
- Quine, W. V. O. (1951). Two dogmas of empiricism. *The Philosophical Review*, 60(1):20–43.
- Ramachandran, V. S. and Hubbard, E. M. (2001). Synaesthesia – a window into perception, thought and language. *Journal of Consciousness Studies*, 8(12):3–34.

- Rosenblueth, A. and Wiener, N. (1945). The role of models in science. *Philosophy of Science*, 12(4):316–321.
- Smith, J. Z. (1990). *Drudgery Divine: On the Comparison of Early Christianities and the Religions of Late Antiquity*. University of Chicago Press, Chicago.
- van Fraassen, B. C. (1988). The pragmatic theory of explanation. In Pitt, J. C., editor, *Theories of Explanation*, pages 135–155. Oxford University Press, New York.
- Woodward, J. (2003). *Making Things Happen: A Theory of Causal Explanation*. Oxford University Press, New York.

5 Appendix

5.1 Terminology issues

I have made rather idiosyncratic choices in naming the four archetypes of explanation discussed here, even though I believe they are already well established either in the forefront or in the background of many scientific and philosophical corpora. Picking my own terms was a motivated decision, an attempt to prevent or minimize some confusions that have kept arising up to now in my conversations on this topic.

The compositional type is very strongly associated with “reductionist” science, but I avoid this term which can also refer to any reduction of one object or field to another (e.g. psychology to anatomy, or algebra and geometry to set theory) without assuming a part-whole relationship between them. In addition, reductionism is commonly opposed to emergence, while both are instances (respectively shallow and deep) of compositional explanation.

“Context” is commonly used (notably in biology) to encompass roughly everything that is not compositional in my schema: Montévil (2019) uses various subtypes of context (phylogenetic, historical, current) that combine what I would rather classify as contingent variation, comparison to singular entities, and context in my sense of a whole-to-part explanation. Here, it is restricted to a nebula of ideas such as functionalism and teleology, selection, role, goal, purpose and meaning, many of which are either confusing or proscribed from serious scientific discourse (e.g. the mainstream opinion on teleology in biology), inhibiting many researchers’ ability to use this type rigorously. I am hoping that my choice of words can defuse these controversies to some degree, and highlight the continuity with far milder concepts such as the boundary conditions of physics.

Comparison is used here in a technical sense, and was a difficult choice. I use it to designate explanations that empower us by allowing to recognize singularity and similarity, to find salient features in the undifferentiated thingness of any thing, and transfer inferences and insights that we have learned from other

things. Comparison in the usual sense is just one step or tool in this process, of complicated standing among other tools such as metaphor or analogy, ontology, chronology, typology or mereology.

5.2 Inverse problems

An inverse problem is one where we take a method meant to explain some target X from some source Y , and instead use it to understand more about the source. I mention inverse problems here because I believe they are responsible for confusions between the different archetypes.

To start with a (hopefully) non-confused example in contingency-based explanations: when we want to understand the history of some entity X , a useful approach is identifying fingerprints that reveal that some event Y happened instead of some Y' , such as literal fingerprints in a forensic setting, or ‘neutral’ markers in a biological or cultural setting (features that can be treated as accidental, e.g. non-selected parts of the genome) that track historical divergences while being unaffected by either composition or context. By showing that some Y is a good marker of the history of X , we are actually learning something about the source Y itself (e.g. that it is not under natural selection).

To move on to confusions, when presenting contextual explanations in my model, I have been offered examples such as chemical functions or host range: in the former case, we take an unknown chemical and test it in a variety of contexts to see what it does; in the latter, we take an unknown virus and test it in various hosts to see who it infects. In both cases, I argued back, this is entirely missing what I would call a contextual role, which is precisely what is *lost* when we take the same object and put it in a different context, and retained when we put a different object in the same context and get the same result. What these methods characterize, instead, is the unique identity of the chemical or virus which is being moved around, which is in some sense compositional, or at least in bijection with normal compositional understanding (i.e. once I know what the functional group or virus is made of, this should tell me how it reacts in various contexts, even if we do not want to simply accept “the list of who I can infect” as a compositional description¹⁷).

5.3 Abstraction and formalization

Besides generality and particularity, another common distinction made between different thinking styles is how abstract and formalized they are, from practical know-how to mathematical theories.

I claim that all archetypes can be used abstractly or concretely: this relates more to the distance between source and target, or equivalently, how many details about the source are relevant or irrelevant, i.e. negative and neutral analogy *sensu* Hesse (1963). I will expand on this point in other work, but intuitively, using an ant to think about another ant, or about anthills or ant organs,

¹⁷A useful analogy may be the notion of *type* in computer science.

is rather concrete; whereas using microscopic balls to think about macroscopic fluid dynamics, or an algebraic formula to think about a geometric problem or a physical object, is rather abstract. I thus make the notion of abstraction dependent on a judgment of similarity or distance, anchored in comparison, consistently with my overall comparative approach to epistemology.

Formalization is a different issue. In our current scientific culture, formalization largely means using general compositional laws, and within the domain of composition, focusing on relations rather than essences. But I believe this is largely a historical byproduct of mathematics developing mainly with the sciences of composition, and potentially bound to change.

5.4 Diachrony, causality and dynamics

Any archetype can address synchrony or diachrony, objects in space or trajectories in time. To illustrate this for diachrony, we can decompose a year into seasons, investigate the function of an action in a plan or a chord in a song, record a chronology of accidents, or compare two dynasties. History in the sense of a diachronic trajectory is not attached to any archetype, even though history as a field is aligned with one (or two) of them.

However, accidents are necessary to even define a direction of causality and time (Albert, 2000). Thus, any diachronic description whose direction matters contains at least a hint of contingency: decomposing a year into seasons does not rely on the arrow of time, but the role of an action in a plan does.

A dynamical model typically starts from a compositional description of the system's state in terms of all its parts or atoms, and explores how it changes by positing necessary relations between the variables at $t + dt$ and all possible values that they might take at t , over a single time increment (again, an 'atom' of duration). No reference to earlier history is needed, as all memory of relevant events prior to t is assumed to be encoded in the compositional state at t . Contingency thus appears in two minimal ways: the initial condition always needs to be specified, and experimental tests rely on perturbing the system (imposing various initial conditions) to explore counterfactual trajectories¹⁸.

5.5 Goal-directedness

I only touch on goal-directedness because of its interesting symmetry with dynamics. Agents such as living beings are often described as deploying a kind of reverse causality, i.e. the future causing the past, since their behavior is goal-directed, taking action now to bring about some desired future. I propose to instead interpret this as an example of contextual explanation in a time-directed setting. Explaining an action by its purpose, i.e. how it fits in a longer-running plan, is a form of appeal to context. Treating time as just another dimension of space is rather natural in some sciences; the temporal character does not

¹⁸In physics, fluctuation-response theorems draw important connections between the way that the system responds to such an accident and the way that it behaves intrinsically, connecting contingency and necessity.

necessarily imply that an element of contingency has to be introduced. Yet the idea of reacting to contingency, being able to adapt plans to reach the same goal when conditions change, seems like an important feature of agents (and one way that they are discriminated from mechanical feedback loops). This may participate in intuitions, going back to Aristotle, tying luck or fate with agency, i.e. a contingent explanation hiding behind a naive contextual intuition.

5.6 Memory

In another deep hybridization of contingency and composition, sciences such as historical phonology and genetics track contingent histories among possibilities that form not just a set (e.g. the outcomes of a coin toss) but a combinatorial space: possible words are combinations of a few basic sounds, possible genomes are combinations of a few basic codons and mutations. The compositional structure of each entity then serves to hold the memory of past history, which can be altered or erased by other accidents. This approach therefore works better with the genome, which is large enough to hold almost arbitrarily long memory, than with words which are quite short and with many possibilities for erasure: genetic mutations are remembered for very long time, in the sense that very ancient ones can still be deduced by comparing current compositions (using techniques of sequence alignment).

5.7 Constraints

Constraints are statements which limit the possible joint states of entities. The ideal gas law $PV = NkT$ entails that only some values of variables P , V , N and T (pressure, volume, quantity of matter, temperature) can occur together, while others are forbidden. This is a statement about necessity, but an noncausal one – it does not state whether, say, P is causing T or the reverse. The relations between these entities are not part-to-whole in either direction, but rather, they are together parts of a whole. Thus, equilibrium thermodynamics seem to combine:

- composition – we define a system as the joint state of the relevant entities making it up (P, V, N, T) ,
- context – we are mainly interested in which states these entities can or cannot explore due to being part of a system with certain externally-imposed conditions (adiabatic, isothermal, etc.). Starting from $PV = NkT$ to deduce some expectation about temperature T or pressure P alone is starting from the whole to explain the part.

Other examples of a similar nature include all equilibrium relations in physics and beyond (e.g. $U = RI$ in electrostatics), but also variational principles (light takes the fastest path between two points) and conservation laws and symmetries.

This list shows that noncausal explanation is a major modality in science, despite the usual focus on causality, and all these examples share the feature that a space of configurations is described compositionally (e.g. which variables we consider together, which paths light can take) then restricted by a constraint from the whole. Most of the effort usually lies in the compositional description, with the constraint (fastest path, etc.) being usually stated in terms of the compositional variables (Barbier, 2026), which suggests to me that this remains a composition-dominant hybrid as shown in Fig. 3.