

# Between Fact and Feeling: The Role of Metaphor in Scientific Understanding

Ravindra Singh<sup>1</sup>, Anjali Ramaria<sup>2</sup>

<sup>1</sup>Assistant Professor, School of Arts and Humanities, Career Point University, Kota (Raj.)

<sup>2</sup>Associate Professor, School of Arts and Humanities, Career Point University, Kota (Raj.)

**Abstract**—This paper begins the interrogation of the epistemic role of metaphor in scientific thought by arguing against the prevailing assumption that metaphor is merely illustrative or acts as a cognitive tool. In its place, it posits metaphor as foundational to the scientific understanding, mediating between abstraction and embodiment, cognition and affect. Through interdisciplinary analysis based in the philosophy of science, cognitive theory, and textual interpretation, the paper explores how metaphor operates not only in communication but also in the very constitution of scientific knowledge. Drawing on case studies from physics, life sciences, and neuroscience, it demonstrates that metaphor is central to theory formation, discovery, and affective resonance. The paper also critically examines the risks of metaphor, including distortion, reification, and ideological inscription, particularly when metaphors migrate unexamined into public discourse and policy. In response, it proposes a “poetics of scientific knowledge” that foregrounds metaphor as a site of imaginative reasoning, ethical reflection, and epistemic humility. Rather than treating metaphor as a deviation from scientific rationality, the paper attempts to reclaim it as a condition of intelligibility, inviting a more reflexive, plural, and affectively attuned approach to knowledge production.

**Index Terms**—Affect Theory, Critical Science Studies, Cognitive Theory Epistemology, Metaphor, Scientific Knowledge, And Poetics Of Science

## I. INTRODUCTION

What does it mean to call the brain a computer or genes selfish? These are not merely decorative figures of speech. They are conceptual models that help scientists formulate hypotheses, communicate ideas, and interpret evidence. The brain-as-computer model, for example, has influenced research programs in cognitive science, neurobiology, and artificial

intelligence by suggesting that mental processes can be analyzed as computations. Similarly, Dawkins’s phrase “the selfish gene” (1976) has had wide cultural and scientific influence. It gives a new turn to evolution from the gene’s perspective and uses the language of competition and apparent purpose, though genes themselves are not conscious agents. Such metaphors can blur distinctions between description and evaluation, and between theoretical explanation and narrative. Hence, it would appear that metaphor is not superadded to scientific discourse from without, but is itself among the powers by which that discourse is constituted.

The dominant narrative in the philosophy of science has long sought to divorce scientific language from metaphorical or imaginative forms of expression. From the Enlightenment onward, science has presented itself as the domain of precision, literalism, and dispassionate objectivity, a realm of pure fact, scrubbed clean of affect and ambiguity. This epistemological ideal, exemplified in the legacy of logical positivism, presumes that metaphor belongs to the realm of the literary or emotional and that its presence in science is an aesthetic excess or temporary heuristic. Such assumptions sustain a Cartesian bifurcation between reason and emotion, undermining the complex ways in which metaphor not only aids in scientific communication but also shapes scientific cognition.

This paper interrogates that bifurcation by posing three central questions: First, how do metaphors operate within scientific theorization? Second, can metaphor be epistemologically legitimate, or is it merely heuristic and pedagogical? And third, what does the persistent presence of metaphor in science reveal about the embodied and affective dimensions of knowledge production? These questions are not

merely rhetorical but foundational to understanding how science conceptualizes reality and communicates it. For instance, when physicists speak of "curved spacetime" or biologists of the "genetic code," they are not simply describing observable facts but organizing and interpreting data through culturally and cognitively mediated frames.

This paper argues that metaphors are not ornamental additions to science but are essential to its structure of understanding. They are cognitive instruments that allow scientists to imagine phenomena beyond the reach of direct perception, to frame hypotheses, and to construct theoretical models. Metaphors thus blend cognition with imagination, fact with feeling, enabling science to articulate the invisible, the abstract, and the complex. Following Max Black's interaction theory of metaphor (1962), which posits that metaphor involves a mutual interaction between two domains rather than a one-way transfer of attributes, this paper contends that metaphor actively shapes how scientific concepts are formed and refined. Similarly, building on Lakoff and Johnson's (1980) work in conceptual metaphor theory, which argues that all abstract thought is grounded in metaphorical mappings rooted in embodied experience, the paper situates metaphor as central to both the formation and the communication of scientific knowledge.

The methodological approach adopted here is interdisciplinary, drawing from philosophy of science, cognitive linguistics, and critical textual analysis of scientific and popular-scientific literature. It engages canonical theorists such as Mary Hesse (1966), Thomas Kuhn (1962), and Evelyn Fox Keller (1985), while also incorporating contemporary cognitive theorists and historians of science. This multi-pronged methodology allows for a nuanced exploration of metaphor not just as a rhetorical device but as an epistemic practice that reveals the poetic undercurrents of scientific rationality.

In re-evaluating metaphor's place within scientific knowledge, this paper resists the tidy division between objectivity and affect, and instead proposes a poetics of science—one that recognizes metaphor as a site where imagination and reason cohabit, and where knowledge itself emerges through the interplay of symbolic thought and empirical inquiry.

## II. THEORETICAL FOUNDATIONS: METAPHOR, COGNITION, AND SCIENTIFIC EPISTEMOLOGY

### 2.1 Historical Suspicion of Metaphor in Science

Within the classical epistemology of science, metaphor has long been treated with ambivalence if not outright suspicion. This distrust can be traced back to early modern empiricism, where Francis Bacon (1620/2000), in *Novum Organum*, warned against the "idols of the marketplace," a term he used to describe the distortions of language that threaten clarity of thought. Descartes, too, privileged mathematical clarity and distrusted rhetorical embellishment, seeking a language of pure reason that would eliminate ambiguity (Descartes, 1637/2008). This Enlightenment rationality enshrined literalism as a hallmark of objective thought and positioned metaphor as an obstacle to scientific clarity.

This ethos continued into the 20th century with the advent of logical positivism, particularly in the Vienna Circle, where language was divided into observational and theoretical terms, with a strong preference for the former. Metaphor, along with analogy, was viewed as a provisional tool—useful in early stages of hypothesis formation but ultimately to be discarded in favor of precise, formalized language (Ayer, 1936). The underlying belief was that true scientific statements must be verifiable, denotative, and immune to the slippages of poetic expression.

Yet this ideal of metaphor-free science is, as Mary Hesse (1966) argued, largely illusory. Indeed, many foundational scientific concepts, such as force, field, wave, particle, and string, are deeply saturated with metaphoric associations derived from sensory experience and pre-scientific language. The aspiration for a purified scientific language overlooks the historical and linguistic fact that many of the foundational terms in science emerged through metaphorical transference from ordinary experience to abstract phenomena.

### 2.2 The Cognitive Turn: From Language to Thought

The latter half of the 20th century witnessed a paradigm shift in how metaphor was understood, especially through the rise of cognitive linguistics. With the publication of *Metaphors, We Live By* (1980), George Lakoff and Mark Johnson challenged the traditional view that metaphor is merely

ornamental or linguistic. Instead, they proposed that metaphor is constitutive of human thought, not just its expression. According to them, abstract reasoning, particularly in domains like time, causality, and emotion, is structured through conceptual metaphors, such as “Time is Money” or “Ideas are Objects.”

Science, in this view, is not exempt from metaphorical cognition. Rather, it is one of the most metaphor-intensive domains of human activity. Consider how scientific reasoning often depends on conceptual mappings from the physical world to abstract domains: heat behaves like a fluid, electric current flows, and the mind stores information. These mappings are not merely illustrative but foundational, insofar as they frame how phenomena are conceptualized, what questions are asked, and how explanations are constructed (Gentner & Jeziorski, 1993). Moreover, the embodied cognition hypothesis argues that our ability to reason about abstract concepts, including scientific ones, is grounded in bodily experience. Johnson (2007), expanding on his earlier work with Lakoff, emphasizes that metaphoric structures are rooted in sensorimotor schemas, our bodily interactions with the world, which are then projected onto abstract domains. In this framework, the metaphor is not an impediment to scientific thought but its very condition of possibility.

### 2.3 Metaphor and Model-Building in the Philosophy of Science

Philosophers of science have increasingly recognized the centrality of metaphor and analogy in theory construction. Max Black’s (1962) interaction theory challenged the “substitution view” of metaphor, which treats metaphors as reducible to literal paraphrase. Instead, Black argued that in a metaphor, the two terms (the “tenor” and the “vehicle”) interact in ways that generate new meaning; the metaphor “organizes our view of the subject” by projecting implications from one domain onto another. In science, this projection is often the basis for model-building, allowing researchers to render complex systems intelligible by analogy with more familiar ones.

Mary Hesse (1966) extended this view by demonstrating how scientific models, such as Bohr’s model of the atom or the kinetic theory of gases, are inherently metaphorical insofar as they involve selective structural correspondence between the model and the target system. For Hesse, metaphors are not

disposable instruments but integral to the logic of scientific explanation. They function not only heuristically but also epistemically, enabling scientists to generate hypotheses and interpret data within a coherent framework. Thomas Kuhn (1962) further complicated the picture by showing how scientific paradigms themselves are laden with metaphorical worldviews. His notion of “paradigm shifts” highlighted the incommensurability between successive scientific theories, suggesting that what counts as evidence, explanation, or even reality changes depending on the underlying metaphorical and conceptual structures. In this sense, metaphors are not peripheral, for they are rooted in the ontological and epistemic commitments of scientific worldviews. Taken together, these developments mark a decisive shift away from the ideal of a metaphor-free science. Instead, metaphor is now recognized as an epistemic engine, essential to the generation, communication, and evolution of scientific knowledge. Far from clouding clarity, metaphor structures cognition; far from misleading, it often illuminates. Thus, it is imperative to examine how metaphor operates within specific domains of scientific inquiry—namely, physics, biology, and neuroscience—as this reveals that even the most rigorously empirical sciences rely on metaphor not only as a communicative tool but as a mode of thought.

## III. METAPHOR IN ACTION: CASE STUDIES FROM SCIENTIFIC DISCOURSE

Metaphors in science do not merely embellish. They actively structure how phenomena are conceptualized, categorized, and communicated. They guide observation, shape theoretical commitments, and influence public reception. To grasp the full epistemic force of metaphor in science, we must turn to three compelling case studies, drawn from physics, biology, and neuroscience, which make it unmistakably clear that metaphor is not peripheral but foundational to scientific discourse, repeatedly blurring the line between the literal and the figurative.

### 3.1 Physics: “Wave-Particle Duality” and the “Fabric of Spacetime”

Quantum mechanics presents one of the most striking examples of metaphorical reasoning in science. The term “wave-particle duality” used to describe the behavior of quantum entities like electrons and

photons—attempts to capture phenomena that do not comfortably fit into classical physical categories. As Bohr himself admitted, quantum entities display properties that are wave-like under certain experimental conditions and particle-like under others (Bohr, 1949). The metaphor of "duality" does not resolve the ontological tension; rather, it frames it, providing scientists with a conceptual handle on a counterintuitive reality.

Another emblematic metaphor is "the fabric of spacetime," which appears frequently in both popular and technical physics literature. General relativity describes gravity not as a force but as a curvature in spacetime caused by mass-energy. To make this intelligible, scientists and educators routinely employ metaphors such as a rubber sheet or fabric being stretched and warped by heavy objects. These images do not capture the mathematical precision of Einstein's field equations, but they serve a crucial epistemic role, insofar as they allow non-specialists, and often specialists themselves, to visualize an otherwise abstract geometrical concept (Thibault & Barnett, 2020).

Metaphors like "fabric" and "curvature" carry affective and sensory associations that ground abstract mathematical ideas in bodily experience. As Keller (1985) notes, metaphors in physics often retain traces of the mechanistic worldview they helped overturn, indicating that metaphorical thinking evolves with, rather than against, paradigm shifts.

### 3.2 Biology: "Genetic Code" and "Selfish Gene"

In molecular biology, the metaphor of the "genetic code" has been central to understanding DNA and protein synthesis. Referring to DNA as a "code" or "blueprint" implicitly compares genes to language or software—systems of discrete, symbolically interpretable information. This metaphor frames genes as carriers of deterministic instructions, evoking images of control, hierarchy, and design (Kay, 2000). While enormously productive, it also imposes limits: it obscures the stochastic, probabilistic, and environmentally interactive aspects of gene expression.

Richard Dawkins's (1976) "selfish gene" metaphor takes anthropomorphism a step further. Here, genes are imagined as agents pursuing their survival, even at the expense of the organism. Dawkins clarified that he was not imputing consciousness or intent to genes, yet

the metaphor took on a life of its own in public discourse. It aligned biological processes with neoliberal individualism, naturalizing competition, and self-interest (Lewontin, 1991). The metaphor thus does not merely illustrate a theory; it co-produces an ontology and an ethic. This reveals a key tension in scientific metaphor: it can illuminate molecular mechanisms while simultaneously smuggling in ideological residues. As Haraway (1997) argues, metaphors are "world-making" devices that can reinforce or challenge dominant social imaginaries. The "selfish gene" metaphor, for instance, reifies the gene as the primary unit of selection and minimizes ecological or symbiotic perspectives in evolutionary theory.

### 3.3 Neuroscience: "The Brain as Computer"

The dominant metaphor in contemporary neuroscience likens the human brain to a computer, that is, an information-processing machine that encodes, stores, and retrieves data. Originating in the mid-20th century alongside the rise of cybernetics and digital computing, this metaphor has powerfully shaped the development of cognitive science and artificial intelligence. Terms such as "neural encoding," "input," "storage," and "retrieval" permeate both experimental design and theoretical modeling (Bechtel, 2001).

While the brain-as-computer metaphor has enabled breakthroughs in modeling cognitive functions, it also risks flattening the complexity of consciousness and affect. By reducing neural activity to computation, it overlooks the embodied, affective, and plastic dimensions of brain function. Critics argue that this metaphor privileges a disembodied, mechanistic model of cognition that excludes social, cultural, and ecological influences on mental life (Varela, Thompson, & Rosch, 1991). Moreover, the metaphor carries epistemological implications for what counts as knowledge. If the brain is a machine, then human understanding becomes a matter of signal fidelity, not interpretation or meaning-making. This reductionist logic has implications for how psychiatric disorders are understood (as software glitches or hardware malfunctions), how education is structured (as optimization of input), and how intelligence is assessed (as processing speed or storage capacity).

These case studies reveal that metaphor in science is neither accidental nor decorative, for it is constitutive.

From the curvature of spacetime to the selfishness of genes and the circuitry of thought, metaphor provides the conceptual scaffolding through which scientific understanding is scaffolded and extended. However, as each case demonstrates, metaphors carry epistemic affordances and ideological shadows: they help make sense of complexity, but also constrain what is imagined, investigated, and believed.

#### IV. EPISTEMIC FUNCTIONS OF METAPHOR

While metaphor has historically been dismissed as a merely rhetorical or illustrative device, contemporary scholarship in the philosophy of science and cognitive theory has revealed its epistemic depth. Far from being peripheral to scientific understanding, metaphor plays a generative role in discovery, theory formation, and the emotional intelligibility of abstract ideas. This section delineates three major epistemic functions of metaphor in science: as heuristic and generative, as central to theory construction, and as a conduit for affect and aesthetic resonance.

##### 4.1 Heuristic and Generative Roles

Metaphor often functions heuristically that is, as a problem-solving strategy that guides inquiry before formal hypotheses can be formulated. One of the most cited historical examples is August Kekulé's dream of a snake biting its tail, which led him to the cyclic structure of the benzene molecule. Though the story may border on myth, it illustrates how metaphoric imagination precedes and informs rational articulation (Kekulé, 1890/1966). The image was not evidence in itself but a heuristic device that revealed possible structural symmetries in chemical bonding.

Similarly, James Clerk Maxwell developed his electromagnetic field theory through the use of mechanical analogies and fluid metaphors. In his 1861 paper, Maxwell used the model of a system of rotating vortices and idle wheels to explore the behavior of electric and magnetic forces. While these mechanical models were eventually replaced by more abstract formulations, they played a generative role in articulating field theory (Hesse, 1966). The metaphors did not merely "illustrate" the field they enabled its theoretical birth.

As philosopher Nancy Nersessian (2008) argues, scientific creativity often involves model-based Reasoning that employs analogies and metaphors to simulate unfamiliar systems. These are not merely

decorative images but serve as cognitive tools, enabling researchers to extend their reasoning into unseen, untested, and often counterintuitive areas. Therefore, metaphor is essential not only for spreading knowledge but also for its development.

##### 4.2 Metaphor and Theory Formation

Metaphor not only assists in the genesis of hypotheses. In addition to other functions, this process organizes and shapes the foundational framework upon which scientific theories are built and subsequently understood. Theoretical terms often begin as metaphorical projections and later become naturalized within the scientific lexicon. For instance, the term "black hole" was originally coined by physicist John Wheeler in the 1960s as a metaphor for a region of spacetime from which nothing could escape. Over time, the metaphor solidified into a technical term, embedded in the field's formal discourse (Bartusiak, 2015). What begins as a metaphor gradually acquires ontological status.

This process has led Max Black (1962) and Richard Boyd (1993) to argue that scientific metaphors can be "theory-constitutive." Boyd, in particular, insists that metaphor is not simply heuristic but epistemically indispensable that is, integral to expressing and revising theoretical commitments. He claims that "theoretical realism requires that we take metaphor seriously," especially in fields like quantum physics, where literal description breaks down under the weight of probabilistic and non-local phenomena.

Metaphors often work syntagmatically within larger theoretical frameworks, knitting together disparate domains under shared conceptual schemata. For example, in evolutionary biology, metaphors of "arms races," "battlegrounds," and "strategies" construct a Darwinian narrative of competitive interaction. These metaphors shape research agendas, define ontological units (e.g., "selfish gene"), and influence which phenomena are prioritized or rendered invisible.

Thus, metaphor is not epistemically neutral it contributes to what Bruno Latour (1987) would call the construction of scientific facts, embedding social, cultural, and linguistic choices within the fabric of theory itself.

##### 4.3 Affective and Aesthetic Dimensions

Beyond its cognitive and conceptual functions, metaphor plays a vital role in making science

effectively resonant and aesthetically meaningful. As Paul Ricoeur (1977) argued, metaphor is not only a semantic innovation but a “discovery of meaning” “a poetic intensification that renders abstract concepts sensuously and emotionally graspable. In science, this affective function is crucial for education, public engagement, and internal motivation within scientific communities.

Consider Carl Sagan’s evocative description of Earth as “a pale blue dot,” or Stephen Hawking’s metaphor of “imaginary time.” Such metaphors do not simply convey data they invoke wonder, ethical reflection, and a sense of cosmic scale. The metaphor “code of life” in genetics, for instance, endows DNA with an almost sacred aura, infusing the biological with cultural and emotional valence (Kay, 2000).

Even within the laboratory, metaphors shape how phenomena are felt. Donna Haraway (1997) emphasizes the emotional charge of metaphors like “OncoMouse™,” which not only describes but produces affective relationships between researchers and experimental subjects. Metaphors construct moral geographies, shaping how scientists relate to their objects of inquiry.

Moreover, metaphors serve an aesthetic function they make theories “beautiful,” “elegant,” or “parsimonious.” As physicist Paul Dirac famously suggested, “It is more important to have beauty in one’s equations than to have them fit experiment” (Farmelo, 2009, p. 228). The poetic economy of metaphor thus intersects with scientific values, revealing that the line between rational clarity and aesthetic allure is often indistinct.

Metaphors in science are not ancillary they are epistemically central. They guide inquiry, shape theory, and give emotional and aesthetic texture to knowledge. They help scientists think what they cannot yet see, articulate the ineffable, and animate the inert. In doing so, metaphor discloses a dimension of scientific reasoning that is imaginative, embodied, and affect-laden. The next section will consider the risks and critiques of metaphor in science, addressing how metaphors can distort, reify, or carry ideological biases.

## V. RISKS AND CRITIQUES: THE DOUBLE-EDGED SWORD OF METAPHOR IN SCIENCE

While metaphor is indispensable to the architecture of scientific thought, it is not epistemically innocent. The same rhetorical devices that generate conceptual breakthroughs can also entrench misleading assumptions, reinforce ideological frames, and limit imaginative alternatives. This section outlines three major categories of critique: metaphor as distortion, metaphor as reification, and metaphor as a site of political and ideological inscription.

### 5.1 Metaphor as Distortion

The most immediate critique is that metaphors can distort or oversimplify complex scientific phenomena. Because metaphor operates by analogy, mapping features from a familiar source domain onto an unfamiliar target domain, it inevitably directs attention to certain aspects while obscuring others (Lakoff & Johnson, 1980). This process is productive but also selectively reductive, introducing epistemic blind spots. Consider the metaphor “junk DNA,” coined in the 1970s, for example, to refer to non-coding regions of the genome. For decades, this label implied that vast stretches of genetic material were functionally irrelevant. Subsequent discoveries in epigenetics and regulatory sequences revealed that so-called “junk” DNA plays vital roles in gene expression and cellular behavior (Mattick, 2001). The metaphor not only shaped research priorities but also prejudged the ontological status of genomic material based on an economic metaphor of waste.

Similarly, military metaphors in immunology, such as “defense,” “invasion,” and “surveillance”—cast the immune system as a national security apparatus. While useful for explaining pathogen response, these metaphors obscure phenomena such as immune tolerance, symbiosis, and autoimmunity (Martin, 1994). They simplify a complex ecology of intra-organismic negotiation into a binary of enemy and protector. As Evelyn Fox Keller (1995) argues, metaphors in science often “seduce the mind” by being cognitively convenient, and can oversimplify empirical details. This seduction is not trivial; it can shape entire experimental paradigms, direct funding, and delay paradigm shifts by making some questions unaskable within the existing metaphorical frame.

### 5.2 Metaphor and Reification

Metaphors become particularly problematic when they undergo reification that is, when provisional or illustrative terms harden into ontological claims. What begins as a metaphor for thinking becomes a reality assumed. As Haraway (1991) cautions, metaphors can “leap from language to ontology,” giving the illusion that the metaphor is the thing itself. The metaphor of “the brain as computer” (discussed earlier) exemplifies this danger. Initially a helpful analogy for understanding cognitive processing, it has come to dominate neuroscience discourse, often reducing human thought to information processing devoid of context, history, or affect. It also masks significant differences between biological and digital systems: neurons do not “store” memories as files, and there is no centralized processor (Hayles, 1999). Yet, this metaphor continues to inform experimental design, diagnostic categories, and even policy. Reification can also occur when models are mistaken for mechanisms. In climate science, for instance, the use of “carbon footprint” as a metaphor for individual responsibility obscures the systemic, infrastructural dimensions of ecological crisis. The metaphor suggests that individuals “leave marks” on the planet, subtly shifting moral blame from corporate and state actors to personal consumption (Spence, 2005). In such cases, metaphor does not merely distort; it organizes moral and political causality, shaping public perception and scientific accountability.

### 5.3 The Politics of Scientific Language

Metaphor is not politically neutral. It is embedded within ideological, institutional, and cultural matrices, and its use often reflects broader power relations. Feminist and postcolonial theorists have long critiqued the gendered, racialized, and militarized metaphors that saturate scientific discourse (Harding, 1986; Subramaniam, 2001).

Take, for instance, the metaphor of “conquering nature” in the history of science and technology. From Bacon’s *Novum Organum* to contemporary engineering narratives, the natural world has been figured as a feminine domain to be penetrated, subdued, and mastered. Such metaphors are not accidental—they reflect a gendered logic of domination that intersects with colonial and extractivist ideologies (Merchant, 1980). When Galileo compared the telescope to “a means of

seduction” that “unclothed the heavens,” or when Francis Bacon envisioned science as an “inquisition” into nature’s secrets, metaphor was already a political script (Keller, 1985).

Similarly, postcolonial scholars have noted how developmental metaphors (e.g., “developing nations,” “backwards societies”) have scientific currency in economics, biology, and global health. These metaphors reproduce a temporal hierarchy, positioning the Global South as lagging behind the Euro-American “norm” (Adas, 1989). Even in fields like epidemiology or anthropology, metaphors of contagion, primitivism, or “emergence” can inscribe colonial imaginaries onto populations (Anderson, 2006). Thus, metaphors do more than explain: they frame, discipline, and justify. They naturalize hierarchies, stabilize ideologies, and make certain futures imaginable while foreclosing others.

The risks of metaphor are not simply epistemic they are also political and ethical. When metaphors distort, reify, or carry unexamined ideological freight, they constrain not only what is known but also how it is known and to whom it is accountable. Recognizing these risks does not mean rejecting metaphor, but calls for a more reflexive, critical engagement with the metaphoric scaffolding of scientific thought.

## VI. TOWARD A POETICS OF SCIENTIFIC KNOWLEDGE

If metaphor is both indispensable to scientific reasoning and susceptible to distortion and ideological capture, the challenge is not to eliminate metaphor from science but to reimagine our relationship to it. This section outlines the contours of what may be called a poetics of scientific knowledge—a framework that acknowledges metaphor’s generative and affective capacities while cultivating epistemic reflexivity and ethical attentiveness. A poetics of science does not romanticize metaphor, but treats it as a locus of negotiation: between abstraction and embodiment, theory and experience, fact and feeling.

### 6.1 Reclaiming Imagination in Scientific Thought

For centuries, Western epistemology has drawn a sharp line between reason and imagination, relegating the latter to the aesthetic or irrational. This Cartesian split continues to haunt scientific culture, which often valorizes method over metaphor, logic over lyric. Yet, as Stephen Toulmin (1990) argued, this dichotomy

obscures how imagination operates within the heart of scientific innovation not only in moments of conceptual breakthrough but also in the daily labor of modeling, explaining, and teaching.

To speak of a poetics of science, then, is not to displace rigor but to reclaim imagination as a cognitive virtue. This aligns with what philosopher Gaston Bachelard (1938/2002) called the material imagination the capacity to think with and through images that are grounded in sensory and affective life. Metaphors do not merely decorate thought; they extend it, allowing scientists to experiment with conceptual possibility before empirical confirmation.

This view resonates with feminist science studies, where scholars like Sandra Harding (1986) and Donna Haraway (1997) argue for situated knowledge science that acknowledges the partial, embodied, and perspectival nature of knowing. Metaphor, as a figurative and situated form, offers a pathway to such epistemologies: it foregrounds the locatedness of knowledge rather than pretending toward neutrality or universality.

## 6.2 Toward Metaphoric Reflexivity

A poetics of science entails a metaphoric reflexivity a critical attentiveness to the metaphors that structure our thought, shape our disciplines, and mediate our relationships to the world. This means recognizing when a metaphor illuminates and when it obscures, when it opens epistemic space and when it forecloses it.

Mary Hesse's (1966) work already gestures toward this reflexivity when she notes that metaphors in science create internal structures of similarity that define the logic of explanation. But Hesse also insisted on keeping metaphors open to revision, lest they ossify into dogma. Similarly, Max Black's (1962) "interaction theory" implies that metaphors are processes, not products meaning-making devices that invite interpretation rather than dictate it.

This reflexivity becomes particularly urgent when metaphors migrate between science and society, often without scrutiny. As scholars of science communication have noted, metaphors can frame public understanding of issues like climate change, vaccination, or artificial intelligence in ways that are politically charged and emotionally resonant (Nerlich et al., 2002). A poetics of science thus calls not only for internal criticality but for public literacy in

metaphor, where citizens are empowered to question the figures that shape their scientific realities.

## 6.3 Metaphor as Ethical and Aesthetic Praxis

Finally, a poetics of scientific knowledge must be ethical. As Haraway (1991) insists, "It matters what stories make worlds, what worlds make stories." Metaphors are not innocent. They are world-making devices with ontological and moral consequences. To describe the immune system as a "defense network" is to invoke a politics of exclusion; to describe the Earth as "Gaia" is to invoke care, interdependence, and fragility. What if, instead of "conquering" nature, we spoke of collaborating with it? What if, instead of "decoding" the genome, we imagined it as a conversation, ongoing and plural? A poetics of science invites such refigurings, not as sentimental gestures, but as epistemological interventions that open new questions, methods, and solidarities.

It also invites attention to aesthetic form. Metaphors carry rhythm, resonance, and symbolic density. They are tools of precision, not despite but because of their figurality. As Ricoeur (1977) noted, metaphor is a "productive fiction" a way of saying something true by not saying it literally. To think poetically in science is not to be less exact, but to be differently exact, open to meanings that cannot be captured by formula alone. A poetics of scientific knowledge acknowledges that metaphor is neither a contamination of reason nor a decorative afterthought it is the very medium through which abstraction becomes thinkable, and through which feeling enters fact. To cultivate this poetics is to practice science not as a conquest of the world, but as a conversation with it, one in which metaphor is both our compass and our caution. This perspective does not oppose science to poetry, but sees in their convergence a mutual enrichment: imagination without delusion, rigor without reduction. In embracing the metaphorical, science gains not only new models but new modes of humility, creativity, and care.

## Conclusion: Reuniting Reason and Imagination

"What does it mean when we say the brain is a computer, or that genes are selfish?" This provocation, posed at the outset, now bears a deeper resonance. These metaphors, far from being innocent or incidental, are part of the epistemic infrastructure of science. They do not merely adorn explanation; they

co-produce scientific reality, shaping what is seen, known, felt, and done. This paper has traced how metaphor inhabits the core of scientific practice, not just as heuristic shorthand, but as a mode of world-making that fuses cognition with affect, abstraction with embodiment.

Drawing from philosophy of science, cognitive theory, and critical science studies, the argument has unfolded in five movements. First, we examined the historical suspicion of metaphor in science, showing how Enlightenment rationalism marginalized figuration in favor of literalism. Then, through case studies in physics, biology, and neuroscience, we demonstrated metaphor's operative role in scientific discovery and discourse. In exploring its epistemic functions, we saw how metaphor enables conceptual innovation, theory formation, and emotional intelligibility. Yet, these same powers carry risks: metaphor can distort, reify, and naturalize ideology. Hence, the call for a poetics of science, understood as a mode of critical engagement that treats metaphor not as noise in the signal, but as signal in itself. This conclusion, then, is less an ending than a reframing. To acknowledge metaphor's centrality is to deconstruct the false dichotomy between fact and feeling that has long structured scientific modernity. It is to recognize that knowledge is not built on the suppression of imagination but on its disciplined expansion. In this light, metaphor is not a compromise; rather, it is a condition of intelligibility, a bridge between the known and the unknown, between the empirical and the affective.

Nor are these implications confined to theory. In science pedagogy, metaphor can be revalued not merely as a teaching device but as an invitation into conceptual play and ethical reflection. In science communication, greater metaphorical literacy can conduce to public understanding without sacrificing nuance. And in scientific research itself, metaphor awareness can deepen reflexivity, attune practitioners to the partialities of their models, and open space for alternative imaginaries.

Ultimately, to engage with metaphor seriously is to practice science not as domination, but as dialogue, not as the extraction of truth from mute matter, but as an ongoing conversation between language, world, and mind. Metaphor, in this view, is neither escape nor embellishment. It is how we think, how we feel, and how, tentatively and provisionally, we come to know.

## REFERENCES

- [1] Adas, M. *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance*. Cornell University Press, 1989.
- [2] Anderson, W. *Colonial Pathologies: American Tropical Medicine, Race, and Hygiene in the Philippines*. Duke University Press, 2006.
- [3] Bachelard, G. *The Formation of the Scientific Mind: A Contribution to a Psychoanalysis of Objective Knowledge*. Translated by M. McAllester Jones, Clinamen Press, 2002. Originally published 1938.
- [4] Bartusiak, M. *Black Hole: How an Idea Abandoned by Newtonians, Hated by Einstein, and Gambled on by Hawking Became Loved*. Yale University Press, 2015.
- [5] Bechtel, W. "Representations and Cognitive Explanations: Assessing the Dynamicist's Challenge in Cognitive Science." *Cognitive Science*, vol. 25, no. 3, 2001, pp. 349–372. [https://doi.org/10.1207/s15516709cog2503\\_5](https://doi.org/10.1207/s15516709cog2503_5).
- [6] Black, M. *Models and Metaphors: Studies in Language and Philosophy*. Cornell University Press, 1962.
- [7] Bohr, N. "Discussion with Einstein on Epistemological Problems in Atomic Physics." *Albert Einstein: Philosopher–Scientist*, edited by P. A. Schilpp, Open Court, 1949, pp. 201–241.
- [8] Boyd, R. "Metaphor and Theory Change: What Is 'Metaphor' a Metaphor for?" *Metaphor and thought*, 2nd ed., edited by A. Ortony, Cambridge University Press, 1993, pp. 481–532.
- [9] Dawkins, R. *The Selfish Gene*. Oxford University Press, 1976.
- [10] Farmelo, G. *The Strangest Man: The Hidden Life of Paul Dirac, Mystic of the Atom*. Basic Books, 2009.
- [11] Fox Keller, E. *Refiguring Life: Metaphors of Twentieth-Century Biology*. Columbia University Press, 1995.
- [12] Haraway, D. *Simians, Cyborgs, and Women: The Reinvention of Nature*. Routledge, 1991.
- [13] Haraway, D. *\*Modest\_Witness@Second\_Millennium.Fem*

- aleMan©\_Meets\_OncoMouse™: Feminism and Technoscience\*. Routledge, 1997.
- [14] Harding, S. *The Science Question in Feminism*. Cornell University Press, 1986.
- [15] Hayles, N. K. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. University of Chicago Press, 1999.
- [16] Hesse, M. *Models and Analogies in Science*. University of Notre Dame Press, 1966.
- [17] Kay, L. E. *Who Wrote the Book of Life? A History of the Genetic Code*. Stanford University Press, 2000.
- [18] Kekulé, A. "Benzolfest: Rede." *Classics in the Theory of Chemical Combination*, edited by O. T. Benfey, Dover, 1966, pp. 224–226. Originally published 1890.
- [19] Lakoff, G., and M. Johnson. *Metaphors We Live By*. University of Chicago Press, 1980.
- [20] Latour, B. *Science in Action: How to Follow Scientists and Engineers Through Society*. Harvard University Press, 1987.
- [21] Martin, E. *Flexible Bodies: Tracking Immunity in American Culture from the Days of Polio to the Age of AIDS*. Beacon Press, 1994.
- [22] Mattick, J. S. "Non-Coding RNAs: The Architects of Eukaryotic Complexity." *EMBO Reports*, vol. 2, no. 11, 2001, pp. 986–991. <https://doi.org/10.1093/embo-reports/kve230>.
- [23] Merchant, C. *The Death of Nature: Women, Ecology, and the Scientific Revolution*. Harper & Row, 1980.
- [24] Nerlich, B., C. Hamilton, and V. Rowe. "Metaphors in the Public Discourse of Genetics in the UK." *Science Communication*, vol. 24, no. 2, 2002, pp. 126–152. <https://doi.org/10.1177/107554700202400204>.
- [25] Nersessian, N. J. *Creating Scientific Concepts*. MIT Press, 2008.
- [26] Ricoeur, P. *The Rule of Metaphor: Multi-Disciplinary Studies of the Creation of Meaning in Language*. Translated by R. Czerny, University of Toronto Press, 1977.
- [27] Spence, L. J. "The Voluntary Carbon Offset Market: What Is It and Why Does It Matter?" *International Journal of Environmental Studies*, vol. 62, no. 3, 2005, pp. 289–304. <https://doi.org/10.1080/00207230500082151>.
- [28] Subramaniam, B. "Snow Brown and the Seven Detergents: A Metanarrative on Science and the Scientific Method." *Women's Studies Quarterly*, vol. 29, nos. 1–2, 2001, pp. 296–304.
- [29] Thibault, S., and A. Barnett. "The Metaphor of the Rubber Sheet: Visualizing General Relativity in Science Education." *Science & Education*, vol. 29, no. 5, 2020, pp. 1207–1229. <https://doi.org/10.1007/s11191-020-00158-z>.
- [30] Toulmin, S. *Cosmopolis: The Hidden Agenda of Modernity*. University of Chicago Press, 1990.
- [31] Varela, F. J., E. Thompson, and E. Rosch. *The Embodied Mind: Cognitive Science and Human Experience*. MIT Press, 1991.