From Experience to Metaphor, by Way of Imagination

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Abstract

Modern science deals with concepts and techniques that reach far beyond the familiar realm of everyday experience. In attempting to account for the behavior of nature in these extreme situations, scientists are forced to propose dramatically counter-intuitive ideas, views of the universe that would be impossible to invent without the pressure of conforming to data from extreme regions of space and time. Precisely because these ideas seem startling and alien, they can provide unique metaphorical source material for literary creators.

On the surface, science and literature would appear to be, if not precisely opposites, at least quite distinct fields of endeavor. Science searches for an understanding of reality through empirical methods, while literature is in the business of imagining alternatives to the real world. Indeed, the dictionary on my shelf [1] offers this as the relevant definition of *literature*:

> all writings in prose or verse, especially those of an imaginative or critical character, without regard to their excellence: often distinguished from scientific writing, news reporting, etc.

Imagination is key: in science our imagination is shackled by the imperative of conforming to reality, while in literature it is allowed to roam freely.

And yet, these superficially dissimilar fields consistently intersect and speak to each other. Consider this poem by Muriel Rukeyser [2].

The Conjugation of the Paramecium

This has nothing
to do with
propagating

The species
is continued
as so many are
(among the smaller creatures)
by fission

(and this species
is very small
next in order to
the amoeba, the beginning one)

The paramecium
achieves, then,
immortality
by dividing

But when

the paramecium
desires renewal
strength another joy
this is what
the paramecium does:

The paramecium
lies down beside
another paramecium

Slowly inexplicably
the exchange
takes place
in which
some bits
of the nucleus of each
are exchanged

for some bits
of the nucleus
of the other

This is called
the conjugation of the paramecium.

This poem is not an example of elaborate wordplay, or metrical virtuosity, or dense layers of allusion. It draws its strength both from the slightly whimsical subject matter and from its simplicity and directness of language. At first glance, it reads like a straightforward, almost dry description of a natural phenomenon, the conjugation of the paramecium.

But at second glance, the meaning is less literal; it becomes clear that the paramecia of the poem are being put to metaphorical work. The metaphor is invoked in the lines "But when/ the paramecium/ desires renewal/ strength another joy." Paramecia don't *really* desire strength or joy, and not even the most fervent animal-rights activist is likely to claim that this kind of emotional motivation is what drives these monocellular organisms to conjugate. Rather, this seemingly-straightforward poem is taking a phenomenon of the microscopic world – something discovered and described by science, something not directly accessible to our everyday experience – and using it to illuminate, or at least comment on, a directly human activity: the search for comfort or stimulation from another person. Just as real paramecia don't get stressed out and start looking for renewal, real humans don't generally interchange pieces of their genetic material; but the likening of one to the other provides an engaging juxtaposition.

And this is how science, an unapologetically reality-based activity, becomes fruitfully engaged with the work of literary imagination: as *source material* for metaphors. Indeed, it is precisely because science is forced to conform to the natural world that it functions as such a productive supplier of allegorical raw materials. Science itself is not purely a concoction of the human intellect; rather, it arises out of the intense interaction of that intellect with the information provided by observations and experiments. This information can act either as a clue – hinting at a kind of structure that imagination alone would have missed – or as a constraint, ruling out ideas that make immediate sense to us. Science is therefore forced to turn toward concepts and patterns that lay beyond the easy reach of imagination alone. The thesis of this paper is that these ideas are a bountiful source of allegorical inspiration for literary creators.

Since (at least) the beginnings of the scientific revolution, scientific ideas have gone beyond the dictates of common sense. Copernicus, trying to understand the motions of the planets through the sky, was led to propose that the solid Earth itself was moving around the Sun. An even more telling example is provided by the shift in our understanding of motion as developed by Galileo and Newton. In Aristotelian physics, the natural state of a body is to be at rest, and continual motion requires the intervention of a mover. Galileo turned this notion on its head, positing that bodies in motion tended to stay in motion in the absence of forces acting on them, an idea later codified into Newton's First Law of motion. We have become so familiar with Newtonian mechanics that we tend to forget how counterintuitive this idea really is. In the course of everyday life, we do not find objects in states of uniform unforced motion; indeed, when we push briefly on things, they tend to more or less rapidly come to a stop. We attribute this state of affairs to the meddlesome influence of friction, and are confident that the bodies would really prefer to continue along uniform trajectories if it weren't for the intervention of nagging dissipative forces. But this view, as successful as it is, is quite abstract and anti-commonsensical; it stands as a paradigmatic example of the need for physics to overcome the intuitions of our everyday experience.

The separation between scientific ideas and common sense has been greatly accelerated by technological advances in our experimental capabilities. Ever since the invention of the telescope and microscope, scientists have pushed their theories into realms that are literally outside our experience: the very small and the very large, the very fast and the very slow, miniscule effects only discernible by the most precise apparatus. It should come as no surprise that the models of nature we have constructed on the basis of readily available data turn out to be inadequate when confronting these new observations. Consequently, scientists are led to ideas that, without this empirical prodding, we simply never would have thought of: quantum mechanics, curved spacetime, chaos, entropy, genetics, black holes, monocellular organisms.

But although these concepts are in some sense forced on us by the confrontation of our desire to understand the universe with new views of its far-flung corners, they still remain products of the human imagination. We never observe "quantum mechanics" or "curved spacetime"; we observe interference patterns in the double-slit experiment, or the precession of the perihelion of Mercury. Physical theories, in contrast with the data that inspire them, are ultimately human constructs, and as such lend themselves readily to metaphorical uses. Once we are dragged kicking and screaming by observations to the realization that nature behaves in a certain way, it is natural to contemplate the extent to which we ourselves behave in analogous ways[1].

A well-known example of the use of ideas from physics to illuminate the human condition is provided by Thomas Pynchon in his stort story "Entropy" [3]. Callisto, hermetically sealed in his ecologically-balanced city apartment, is dictating his memoirs.

[1]Needless to say, it is important to distinguish between *metaphor* and *description* when relating scientific concepts and terminology to commonplace phenomena. Heisenberg's uncertainty principle is a specific and technical statement about the behavior of quantum observables; it is not merely the truism that people behave differently when you are watching them.

> "Nevertheless," continued Callisto, "he found in entropy, or the measure of disorganization of a closed system, an adequate metaphor to apply to certain phenomena in his own world. He saw, for example, the younger generation responding to Madison Avenue with the same spleen his own had once reserved for Wall Street: and in American 'consumerism' discovered a similar tendency from the least to the most probable, from differentiation to sameness, from ordered individuality to a kind of chaos. He found himself, in short, restating Gibbs' prediction in social terms, and envisioned a heat-death for his culture in which ideas, like heat-energy, would no longer be transferred, since each point in it would ultimately have the same quantity of energy; and intellectual motion would, accordingly, cease."

This is, of course, a particularly self-conscious example of the phenomenon; Pynchon the author uses the concept of entropy metaphorically, while having his character explain the use of entropy as a metphor.

The notion of entropy provides a clear case in which scientific reasoning extrapolates from everyday experience into a realm we don't ordinarily reach, returning with ideas that almost beg to be used in illuminating everday experience itself. We all recognize that turning eggs into omelets is easier than turning omelets into eggs, but only after years of careful research were physicists able to formalize this notion into the science of thermodynamics, with startling consequences. In the late 19th century, Josiah Willard Gibbs proposed the notion of "free energy" – roughly, the energy of a system that one could actually use to do useful work, in contrast to thermodynamically useless forms of energy such as heat. In a closed system, any spontaneous change will inevitably *decrease* the free energy. It is a short journey from there to realize that nature will inevitably run down, as its free energy is gradually used up (although modern cosmology suggests some escape routes [4]). The repercussions of this idea are so fraught with implication that it is surprising that entropy doesn't play a major role in a much wider range of modern literature.

Of course, when a concept is this delicious, it can be difficult to resist the temptation to take the metaphor too far. Indeed, in the introduction to his collection of early stories *Slow Learner* [5], Pynchon explains how he failed to deploy the idea from physics in service of the characters of his story, rather than the other way around:

> Disagreeable as I find "Low-lands" now, it's nothing compared to my bleakness of heart when I have to look at "Entropy." The story is a fine example of a procedural error beginning writers are always being cautioned against. It is simply wrong to begin with a theme, symbol or other abstract unifying agent, and then try to force characters and events to conform to it...
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> I happened to read Norbert Wiener's *The Human Use of Human Beings* (a rewrite for the interested layman of his more technical *Cybernetics*) at about the same time as *The Education of Henry Adams*, and the "theme" of the story is mostly derivative of what these two men had to say. A pose I found congenial in those days – fairly common, I hope, among pre-adults – was that of somber glee at any idea of mass destruction or decline. The modern political thriller genre, in fact, has been known to cash in on such visions of death made large-scale or glamorous. Given my undergraduate mood, Adams's sense of power out of control, coupled with Wiener's spectacle of universal heat-death and mathematical stillness, seemed just the ticket. But the distance and grandiosity of this led me to short-change the humans in the story. I think they come off as synthetic, insufficiently alive. The marital crisis described is once again, like the Flanges', unconvincingly simplified. The lesson is sad, as Dion always sez, but true: get too conceptual, too cute and remote, and your characters die on the page.

The lesson for beginning writers can be sharpened into a suggestion for the deployment of scientific metaphors: if it is true that the workings of nature may suggest provocative parallels with the workings of humans, a story that takes advantage of this provocation need not be explicitly about scientific themes. It could refer to them as background material, or simply take the inspiration from a suggestive scientific concept and put it to use in a completely separate context.

In the twentieth century, as the reach of our experiments has extended significantly further beyond that of our unaided senses, our foundational physical theories have become correspondingly less rooted in common sense. Modern fundamental physics rests on two impressive structures: Einstein's general theory of relativity, which explains gravitation as a manifestation of the curvature of spacetime, and the Standard Model of particle physics, a comprehensive picture of elementary particles that operates in turn within the framework of quantum mechanics. Both general relativity and quantum mechanics are, on the one hand, highly abstract and difficult theories, both in the sense of technical computations and in the sense of interpretational problems relating the formalism to observations; and on the other hand, have been stringently tested to extraordinary precision by a wide variety of experimental probes. The inescapable lesson of these theories is that nature's inner workings depart in very significant ways from those of the subset of phenomena with which most of us are immediately familiar.

The unfamiliar concepts arising from general relativity and quantum mechanics – time dilation, black holes, the expanding universe, the uncertainty principle, quantum entanglement, the collapse of the wavefunction – provide tempting fodder for the writer wishing to explore some of the similarly inscrutable features of human life. Charlotte Jones, in her recent play *Humble Boy* [6], draws on a particularly intriguing aspect of contemporary physics: the apparent *incompatibility* of general relativity and quantum mechanics, these two profound edifices on which our modern understanding of nature rests. As successful as it is, general relativity is an intrinsically classical theory, squarely in the Newtonian mode of a clockwork universe, unreconciled with the deep lessons of quantum mechanics. Our current best attempt at bringing these two structures together is superstring theory, the idea that elementary particles are actually vibrational modes of microscopic loops and segments of one-dimensional "string." Jones, inspired by Brian Greene's popular exposition of string theory in *The Elegant Universe* [7], has written a play whose protagonist is a nervous young string theorist, returned home from his studies in Cambridge after the death of his father.

He poetically explains the nature of his work, relying on metaphors of sound to describe the behavior of superstrings.

> **Felix** I know they're there – the strings – the superstrings – and they will bring everything together into a perfect elegant supersymmetry – the jittery, frenzied world of quantum mechanics and the gentle curving geometry of gravity. You see we know the rules for the big things like the cosmos and we know the rules for the small things like the atom, but the rules don't agree – it's the superstrings that will bring the forces together. The superstrings will give us a quantum theory of gravity – that's what I want, what we all want . . . You know, I'm so close, I can hear them! I can hear the little vibrating strings inside my head.

But the metaphors cut both ways: Felix appeals to the sound of vibrations to illuminate his research in quantum gravity, while the irreconcilable differences between general relativity and quantum mechanics are used as a simile for the personal differences between his mother and father. Later in the play, Felix talks to his ex-girlfriend Rosie about his struggles to understand how these two apparently incompatible people could have ever been brought together [8].

> **Felix** It's like my mother was the big force – gently warping everything around her. And my father was the little force, fizzing away quietly on a microscopic level. But I can't bring them together. I'm trying to understand the extreme conditions that would have brought them together. I mean, I know the geography of it. It was outside the exam halls of the School of B-biology. London University. My father had just finished his Finals and he walked out and my mother was just p-passing. She'd p-paused to light a cigarette. She was on her way to sign up to a modelling agency. He went up to her and asked her if she'd dropped from the sky. She never got to the agency.
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> **Rosie** That doesn't sound so extreme.

> **Felix** But that's not the physics! The physics of what attracted them and what kept them together.

Felix's mother is general relativity, and his father is quantum mechanics. Growing up in an unstable and unhappy household, he couldn't help but wonder how such disparate forces could have ever been attracted to each other, or what kept them together. It is no stretch to imagine how the longing to find some underlying explanation – to understand the physics of this complex relationship – could be projected into a career as a mathematical physicist, struggling to reconcile the forces of nature.

In fact, the appropriateness of Felix's choice of career goes beyond the parallels between his family situation and the subject of his intellectual work. While the *substance* of physics sheds interesting patches of light on the complexity of human interactions, the *process* of physics provides an appealing escape from precisely that complexity. To the non-expert, studying black holes or particle physics can seem impossibly complicated, involving esoteric details of intimidating mathematical technicality. At the same time, however, these recondite ideas have the virtue of being absolutely unambiguous and clear at their cores, at least within the context of a well-posed scientific theory. Black holes are mysterious, but a trained physicist can write down the Schwarzschild metric describing the curvature of spacetime, and study with arbitrary precision the behavior of matter in that spacetime. Physical theories may be complicated, but they are ultimately unequivocal in their pronouncements. In this they are quite unlike human beings. It should come as no surprise that a precocious but introverted child, baffled by the complications and contradictions of his social milieu, would turn to the pristine puzzles of theoretical physics as a kind of refuge. The pleasure gained in mastering the subtleties of nature can be an escape from the mystifications inherent in dealing with real people.

Writers, seduced though they may be by the mysterious and otherworldly implications of ideas derived from scientific research, are not content to simply take such ideas and put them to metaphorical use. At the risk of hypothesizing beyond what the evidence warrants, it occasionally appears as if writers find it hard to resist the temptation to point out perceived shortcomings in scientists' understanding of the world – perhaps especially so for physicists, whose subject matter is the most evidently removed from typical human concerns. These shortcomings, one gathers, center primarily on the marginalization of human feeling and emotion in physicists' theories. In *Humble Boy*, above, it is perhaps not a coincidence that while Felix is a physicist, his father was a biologist, and the fateful encounter between his parents took place outside the School of Biology. A more explicit example is given to us by Tom Stoppard, who (along with Pynchon) is one of the writers most readily identified with scientific themes. In *Arcadia* [9], a play enlivened by numerous references to classical mechanics, entropy, and chaos theory, it is suggested that what's missing from such totalizing frameworks is the power of love.

> **Chloë** That's what I think. The universe is deterministic all right, just like Newton said, I mean it's trying to be, but the only thing going wrong is people fancying people who aren't supposed to be in that part of the plan.
>
> **Valentine** Ah. The attraction that Newton left out. All the way back to the apple in the garden. Yes. (*Pause.*) Yes, I think you're the first person to think of this.

But perhaps this is not after all a criticism, but simply an example of roles being properly played: scientists peer into the hidden corners of nature, and develop elaborate and compelling theories to explain the phenomena they observe, while literary creators take these ideas and both put them to work and illuminate them through parallels with situations at a more human scale. Scientists are not tempted to take advice on how to carry out their research from authors of poetry and fiction, any more than anyone would ever be tempted to seek guidance on love and relationships from accomplished physicists.

If it is true that scientific ideas provide source material for literary metaphors, it doesn't follow that the appearance of the scientific concept in the fictional work need be very explicit. Just as a paradigmatic example of a particularly blunt use of physics in literature is provided by the young Pynchon in his story "Entropy," a compelling example of an extraordinarily subtle use of such inspiration is provided by the mature Pynchon in his novel *Mason & Dixon* [10]. This work concerns the adventures of 18th-century surveyors Charles Mason and Jeremiah Dixon, first as they observe the transit of Venus in southern Africa and later as they map the celebrated line of constant latitude marking the boundary of Pennsylvania and Maryland (and consequently dividing the American North from the South). At one point early in the book, the surveyors puzzle over a letter they have received from the Royal Society:

> "You suppose this is Bradley's voice? I think not, for I know him,—Bradley cannot write like this, even simple social notes give him trouble. '...Whenever their circumstances, now uncertain and eventual, shall happen to be reduced to Certainty.' Not likely."
>
> "Eeh, thah's deep...? 'Reduc'd.' "
>
> "As if,..there were no single Destiny," puzzles Mason, "but rather a choice among a great many possible ones, their number steadily diminishing each time a Choice be made, till at last 'reduc'd,' to the events that do happen to us, as we pass among 'em, thro' Time unredeemable,— much as a Lens, indeed, may receive all the Light from some vast celestial Field of View, and reduce it to a single Point. Suggests an optical person,— your Mr. Bird, perhaps."

Here Pynchon has given just enough of a hint to suggest a metaphor that will recur throughout the book – that of the *collapse of the wavefunction* in quantum mechanics. Mason's description of multiple destinies, steadily diminishing in reality until reduced to a single observed situation, fits perfectly with the conventional Copenhagen interpretation of wavefunction collapse (sometimes referred to as "reduction" of the state vector). One of the most profoundly counter-intuitive features of quantum mechanics is that systems can be in superpositions of ordinary states – a cat that is half alive and half dead, in Schrödinger's famous thought experiment. It is the act of observation that converts these multiple co-existing realities into a single observed truth. Pynchon portrays the westward progress of

Mason and Dixon as a series of such observations – before they cross a certain hill, it is not only conceivable that various fantastic possibilities might describe the other side, but all of these possibilities really do obtain, until the surveyors' actions collapse them into a single reality. Of course, such a manifestly 20th-century notion would appear to be completely anachronistic in a novel set in the 18th century; but Pynchon regularly makes cheerful use of such anachronisms, and there is no reason to believe that he would hesistate to refer to profound ideas of modern physics in a novel about progress at the dawn of the Age of Reason. Science has provided the author with a particularly rich metaphorical idea, and the absence of any explicit discussions of quantum mechanics in the book is no reason not to take advantage of it.

There is, of course, a substantial barrier to the frequent and skillful deployment of scientific ideas in literary works: the simple fact that these ideas are often difficult to understand and shrouded in technical details. A small number of interested authors will make the necessary effort to sift through these details to hit upon provocative ideas and turn them into dramatic creations, but those will always be a minority. Nevertheless, recent years have witnessed a noticeable increase in plays and novels with scientific themes; the success of Michael Frayn's *Copenhagen* [11] and David Auburn's *Proof* [12] provide obvious examples. It is possible that this upsurge in interest can be traced to the corresponding success of popular-science books written by charismatic figures who are also world-class physicists; bestsellers by Stephen Hawking [13] and Roger Penrose [14] set the stage for the popular reception of Greene's book and others.

The responsibility of scientists is to discover how the universe works, but also to come back and let people know what they have discovered. Science does not sit apart from the rest of human activity; it is a craft carried out by ordinary people, and human beings themselves are inextricably part of nature. Science is an aspect of culture as surely as art or music. The universe, like our fellow humans, continually startles us with the fecundity of its imagination, and using what we have discovered about one of these remarkable phenomena to illuminate mysteries of the other is the most natural thing in the world.

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